ESTONIAN UNIVERSITY OF LIFE SCIENCES

Institute of Economics and Social Sciences

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PÕLLUMAJANDUSLIKU TOIDU TARNEAHEL - VEGANLUS JA SELLE MÕJU TOIDU TARNEAHELALE SAKSAMAAL

AGRI-FOOD SUPPLY CHAIN – VEGANISM AND ITS IMPACT ON THE FOOD SUPPLY CHAIN IN GERMANY

Master's thesis

Curriculum in Social Sciences

Supervisor: Anne Põder, *Ph.D*

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The agri-food supply chain is exposed to and influenced by various external factors, causing it to constantly change and evolve. It is important to study and explore these aspects in order to know the ways in which the food system is influenced and the role these elements play in shaping the landscape of this industry. The general aim of the thesis is to explore the impact of the increasing demand for vegan products on the agri-food supply chain using Germany as an example. Literature review is used to review the influencing elements, including the different stakeholders, the global development of the food supply chain, innovations in the food industry, efficiency and environmental aspects, and the impact of the increasing demand for vegan food products on the food supply chain in Germany. The empirical part of the thesis discusses the results of the online survey with 435 respondents. About 63% of the respondents have been following vegan diet for four years or less. The main motives were related to animal welfare and environmental concerns. Ordinary supermarkets were the main places for shopping vegan food. The results suggest that the agri-food supply chain is being influenced and is already responding to the changes caused by the increasing demand for vegan products and veganism as a lifestyle, while more vegan products are entering the market every year. However, high prices and accessibility remain as the main problems for vegans in Germany.

Keywords: Food system, Food Supply Chain, Vegan Diet, Vegan food

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Põllumajanduse ja toidu tarneahelaid mõjutavad erinevad välised tegurid, põhjustades pidevaid muutusi ja arengut. Nende tegurite uurimine on oluline mõistaks, kuidas need mõjutavad toidusüsteemi ning mis rolli need elemendid mängivad tegevusvaldkonna kujundamisel. Magistritöö üldeesmärgiks on välja selgitada, kuidas suurenev nõudlus vegan toodete järgi mõjutab toidu tarneahelat, kasutades selleks Saksamaa näidet. Teaduskirjanduse alusel antakse ülevaade erinevates osapooltest, toidu tarneahela globaalsetest arengutest, toidutööstuse innovatsioonist, efektiivsusest ning keskkondlikest aspektidest ning vegan toodete nõudlusest Saksamaal turul. Töö empiiriline osa käsitleb 435 vastajaga küsitluse tulemusi. Vastanutest 63% olid vegan toitumist jälginud alla nelja aasta. Peamisteks veganluse motiivideks olid loomade heaolu ning keskkonna mõjud. Peamistest vegan toidu ostmiskohtadeks olid tavalised jaepoed. Tulemused näitasid, et toitumisalased muutused mõjutavad toidu tarneahelat ja tarneahel reageerib vegan toodete järgse nõudluse ja elustiili kasvule ning ühe enam vegan tooteid tuleb iga-aastaselt turule. Samas nende kõrge hind ja kättesaadavus on Saksamaal peamisteks probleemideks vegan toitujatele.

Keywords: Food system, Food Supply Chain, Diets, Vegan food

TABLE OF CONTENTS

ABBREVIATIONS AND SYMBOLS

AFNs	Alternative Food Networks
AFSC	Agri-food Supply Chain
AI	Artificial Intelligence
BMD	Bone Mineral Density
CSA	Community Supported Agriculture
ICT	Information and Communication Technology
IFOAM	International Federation of Organic Agriculture Movements
IPCC	Intergovernmental Panel on Climate Change
SCI	Supply Chain Innovation
SCM	Supply Chain Management
SCR	Corporate Social Responsibility
PA	Precision Agriculture

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

A supply chain can be defined as a sequence that includes various stages from decision making and implementation to processing the flow of money, material, and information that aim to meet consumer demand (Roche 2019). The Agri-food supply chain (AFSC) has the responsibility of bringing the food or agricultural products from the farm to the fork.

Although, the agribusiness supply chain includes more than producers and suppliers as it depends on the flow of logistics, transporters, warehouses, retailers, and end consumers. Moreover, the agri-food supply chain covers developing new products, marketing, operations, distribution finance, and customer services. Food and agribusiness chains and networks which tended to be primarily characterized by autonomy and independence of actors are now rapidly moving towards globally interconnected systems with multilayer and complex relationships (Van der Vorst et al, 2007).

From a broader perspective, Supply Chain Management (SCM) consists of combined and coordinated planning, implementing the plans, overseeing all activities and processes that are efficiently influencing the production and delivery while aiming to meet market demand. (Van der Vorst et al, 2007).

The food supply chain is a wide-ranging discussion that involves not only feeding people around the world but also researching and improving methods of food production. It is a valuable issue because the way food is produced greatly affects the environment. Efficiency and innovations that lead to the creation of sustainable means and ways of producing food are what need to be invested in to deal with an issue of such magnitude.

It is clear that the food we consume every day goes through many stages and different actors play their roles along the way. But in the end, it is the consumer who decides whether to buy a product or not, in other words, the consumer is the one who pays for the product, and that money covers all the costs incurred along the way from the farm to the retailer. So the fact that the consumer can significantly influence the entire food chain is undeniable, at least in today's world if not always.

Consumers can influence AFSC in a number of ways. Social behavior, cultural aspects, traditions, religious beliefs, and many other reasons can determine whether or not a product can survive in a particular market. In recent years, it is a dietary shift that is causing significant changes in our food system. The interest of people to consume vegan products is increasing every year. Supermarkets and other retailers are trying to meet this need by creating a separate shelf that contains only plant-based products, as they also try to expand the selection of vegan products. Scientists, researchers, and other experts in the food industry are working to develop new meat substitutes as demand increases.

The gap that this research seeks to fill is that in recent years, many studies have been conducted to address how veganism and the increasing demand for vegan products affect the environment, society, climate, and human health, and even the ethical aspect of this issue has been widely discussed. However, there is little research explaining how the entire supply chain is affected by this dietary trend and how it should respond to deal with this shift in demand that is already taking place.

The research aim of this thesis is to explore the impact of the increasing demand for vegan products on the agri-food supply chain in Germany. The other related topics focusing on the AFSC, in general, are discussed in order to understand the different related aspects that could influence the food industry and the vegan market in particular, using Germany as an example.

Research Objectives

1. To discuss different stakeholders in the agri-food supply chain and their role in achieving sustainability.
2. To provide an overview of the innovations and efficiency in the agri-food supply chain and their relationship to the environment.
3. To provide an overview on what veganism is and what are the main trends related to it and to study the main motives and problems of vegan consumers in Germany
4. To analyze the impact of the increasing demand for vegan products on the agri-food supply chain in Germany.

The information and needed data for the literature review were collected through online search via different platforms such as ResearchGate, Google Scholar, and the online library

(library.emu.ee) of the university. Furthermore, for accessing further literature on the topic books were borrowed from the EMU library. The empirical data necessary for the study was collected using an online survey. The survey was conducted using Google Forms, a questionnaire-building online tool with convenience survey approach.

Quantitative data collected through closed-ended questions were converted into numerical values such as percentages, and the results were analyzed and interpreted to understand and identify trends in customer behavior and its impact on the AFSC. Mostly visual representations like pie charts, clustered bars, and clustered columns were used to show the results of the responses.

The structure of the paper is divided into two main chapters with the theoretical part starting with the literature review, which sets the framework for the rest of the study by discussing previous studies related to the agri-food supply chain. At first, the focus is on a general overview of the AFSC and describes the stakeholders involved. The second subpart describes the innovations in the sector, the third subpart illustrates the efficiency and environmental aspects. Finally, the literature review evaluates the supply chain of vegan products with a focus on Germany.

The second part of the thesis describes the research methodology by explaining the method of data collection and how the collected data was analyzed. It is followed by the results and discussions that highlight the findings and discuss various related aspects of the study, followed by the conclusion and summary.

Acknowledgments

The two-year journey was a great but challenging experience. Many people were directly and indirectly involved in shaping my academic career. Without the valuable support of these individuals, it was hardly possible to get to reach this final step. Here is a small tribute to all those people.

First of all, I would like to express my gratitude to my supervisor Anne Põder Ph.D. for her continuous guidance, which helped me throughout the research and writing of my thesis. In addition to my supervisor, I would also like to thank the director of the institute Prof. Dr. Ants-Hannes Viira, and the thesis committee for their insightful comments and suggestions on this thesis.

I greatly appreciate the help I received from my wonderful and supportive friends, especially in distributing the survey link. Without their help, it would not have been possible to reach so many people and get enough responses. And a special thank you to Eva Scherr, who was always there for me when I needed her and helped me with countless issues related to my thesis.

Last but not least, I am very grateful to my beloved parents, brother, and sisters for their love, encouragement, unwavering support, and belief in me. They made this whole journey possible, there are no words that can express my gratitude for their contribution.

1. LITERATURE REVIEW

1.1 Overview of the agri-food supply chain

The agri-food supply chain is a global network with a high degree of complexity due to rapid perishability, change in food quality at different stages of the chain, unlike other supply chains. It is also characterized by other features such as seasonality, uncertainties on both the supply and demand side, and inconsistencies in the quality and quantity of supply. When it comes to products with long life cycles, it's easy to accurately predict demand, but in the food industry, many products do not last long on the shelf and spoil quickly. In addition, the global demand for fresh food is increasing and supply chain members need to manage this quickly through efficient management (Yu and Nagurney 2013; Childerhouse and Towill, 2000; Van der Vorst 2000).

Yakovleva and Flynn (2004) argue that the food industry supply chain is viewed as a network of interconnected and interrelated organizations alongside a system of different stages that enable the flow of resources, information, and materials in an economic sequence. In other words, food systems such as regulatory agencies, material, and equipment suppliers, and even waste management processes fall under the umbrella of the food supply chain because they have a direct impact on supply chain operations. The food industry, as pointed out by Beske et al. (2014), is an environment known for rapid changes. Nowadays, customers are paying attention with growing awareness to food produced in a sustainable way (considering all three dimensions, i.e. economic, environmental, and social), taking into account all kinds of safety measures.

1.1.1 Description of stakeholders

Stakeholders are not only individuals, but can also include various entities such as organizations, communities, institutions, groups of people, and the natural environment (Tsoulfas et al. 2019). Stakeholders are divided into two categories: primary and secondary stakeholders. Primary stakeholders are directly involved and can include suppliers, partners, investors, debtors, competitors, and customers. Secondary stakeholders, on the other hand, include community

groups, trade unions such as trade union federations, local government representatives, organizations concerned with human rights and environmental issues that are indirectly involved but the company is not necessarily affected by them (Clarkson 1995). Clarkson (1995) also defined stakeholders in his widely cited article by dividing them into two categories.

> *"A primary stakeholder group is one without whose continuing participation the corporation cannot survive as a going concern. Secondary stakeholder groups are defined as those who influence or affect or are influenced or affected by, the corporation, but they are not engaged in transactions with the corporation and are not essential for its survival."*

Roche (2019) takes a similar view on stakeholders as he argues that individuals and agribusinesses involved in the production of agricultural products, starting from farmers to customers, are recognized as stakeholders. These stakeholders could include various agribusinesses involved in different activities along the supply chain such as purchasing, transportation and delivery, warehousing, insurance companies, regulatory agencies, inspectors, grading, assembly, packaging, sales, communication, advertisement, and financing. Besides, grocery stores, restaurants, fast-food chains, and online grocers are also accounted as stakeholders.

The following figure illustrates the connections, relationships, and roles of food industry stakeholders at different stages of the supply chain.

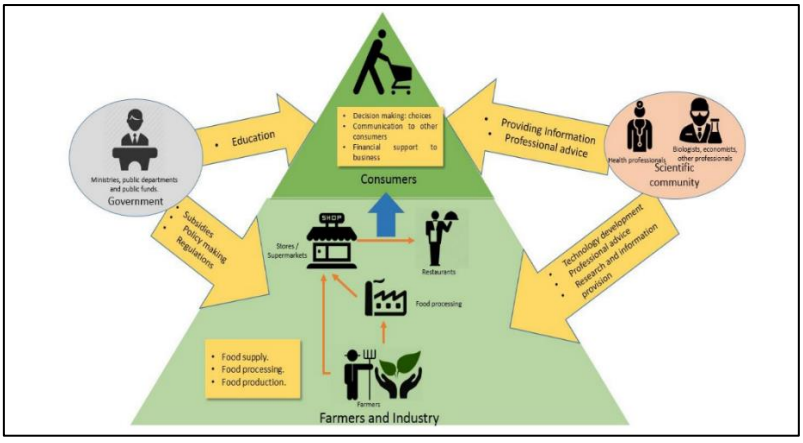


Figure 1. Main stakeholders of the food supply chain and their roles (Gallardo, V. 2015)

1.1.2 Role of stakeholders and changing power in the chain

The agri-food supply chain consists of various activities carried out by stakeholders. These include many activities and procedures throughout the chain, from the farmer to the suppliers, to the manufacturers who add value to the products, to the retailers and distributors who are responsible for delivering the products to the final consumers. In this process, each stakeholder pays a price in return for the benefits, which could sometimes be unjust as some receive more than they deserve and vice versa. Hence, it is important to distribute the benefits in a fair manner through the chain so that some stakeholders do not suffer losses. (Dania et al. 2016).

The development of local food networks requires direct personal relationships with producers, social networking, and consumer education focused on a retro-innovative[1] food culture that promotes respect for quality food and haste-free buying, cooking, and eating. Paloviita's (2010) research concluded that consumers' most preferred products are the ones produced locally in an organic way.

Producers consist of a large number of actors that can be large agribusinesses with a wide range of activities, landowners, tenant farmers, or even a small farm producing agri-food products in both urban and rural areas. (Dubbeling et al. 2016).

Processors which are known to add value to primary products include food manufacturers, meat processors, dairies, fruit and vegetable packers, and many other businesses (Dubbeling et al. 2016).

Wholesalers purchase agricultural products from producers in large quantities so that they can benefit from economies of scale, and they pass these products on to retailers. In addition, farms and processors depend on wholesalers because they require large volume contracts that are necessary to manage their budget plans and yields in advance (Ingram, 2016). Wholesalers usually operate in urban areas but may also exist in some crowded rural areas. Their main activities include storage and resale of products (Terpend and Kouyate 2000).

[1] Retro innovations are the type of innovations that imitate a product or method from the past and update it in a new format that could meet the demand in today's world (Leberecht, 2018).

Transporters are important players in the food supply chain as they are responsible for transporting products from farms or producers to consumption centers. Most producers and growers do not have their own means of transport and rely on the network of transporters that provide delivery services (Terpend and Kouyate 2000).

Retailers in this sector includes a huge range of businesses. From large, international supermarkets with multiple retailers to small independent shops, from informal markets to street food vendors, from home delivery to community bulk buying groups (Dubbeling et al. 2016).

Supermarkets in developed and developing countries there is a rapid growth of supermarket chains, which seems to completely renew the institutional structure of the agri-food production sector. Supermarkets are now the main actors in the AFSC, and they manage and coordinate most of the activities in the network. In the past, however, this was not the case. The buying and selling of agri-food products were done by very small networks in a limited locality of farmers and retail shops, which are now highly displaced by the strong supermarket chains (Van der Vorst et al. 2007).

The number of supermarkets in the EU, the US, and even in developing countries is growing rapidly and, unlike in the past, the global agri-food supply chain is now considered to be buyer-driven (Vlajic et al. 2012). Fundamental changes are needed as the food processing industry grows and expands in a way that a small number of supermarket chains lead the retail food market. Furthermore, it is important to assess how society, the environment, and the economy are affected by these changes (Yakovleva and Flynn 2004).

Catering and consumption consist of various actors such as restaurants, food services, meals provided by the public sector, and canteens. It includes small businesses from street vendors to businesses that operate internationally in various locations such as shopping malls, airports, train stations, etc. (Dubbeling et al. 2016).

Regulators are responsible for regulating food safety, which focuses on the ultimate safety level of products and the standards under which products are processed and produced. However, in developed countries, the roles of regulators have changed significantly in recent decades as the responsibility for the safety of final products has increased (Fieldfisher 2016).

Large retailers are mainly in control of the agri-food supply chain. Although there are many intermediaries in a traditional long supply chain, the large retailers are considered the most influential stakeholders in contrast to a modern short supply chain (Hernández-Rubio et al. 2018). In order to strengthen the supply chain, it is necessary to directly support farmers and invest in the development of transportation, infrastructure, efficient packaging methods, and the expansion of the food industry. Taking these steps could be very helpful in preventing food waste and loss (Roche 2019).

1.1.3 Consumers and agri-food supply chain

In this part, we will study the customer, the person who pays for the product in various places, such as retail stores, supermarkets, local markets, restaurants, takeaways, street vendors, and even on the Internet, online. The idea is to elaborate the basic concepts related to decision-making on the consumer side and analyze them to understand their impact on the agri-food supply chain.

In the agri-food supply network, the main obstacle is to deliver what the customer demands and to satisfy their needs and wants. In order to achieve this rather complex goal, food suppliers need to know more about their customers and use the information gained to understand the motives behind their product choices (Bourlakis and Weightman, 2004)

The role of consumers in the food industry is of great importance because the decisions made by shoppers can affect the entire company that produces a certain product. These decisions end up determining which items are successful or not in the market. Besides, consumers are the driving force in the food market, which makes them the most important part of the entire food network (Asp 1999). Moreover, they are the main source of income and end-users of the chain, which makes them the most valuable actors in the agri-food supply chain (Maloni and Brown 2006).

The choices consumers make when selecting food depend on a variety of factors and change from time to time. These incorporate choices about the location, time, and with whom to eat, and even whether or not to eat. These choices show their way of life, their position in society, and their effect on their physiological and mental health (Marshall, D. 2004).

The choices made by consumers can be driven by several motives, out of all these motives, an important one is a lifestyle which is considered as a factor that determines the identity of the shoppers. Apart from this, according to Asp (1999), food trend also influences the decisions made by the customers. The author also explains the fact that food items are not low involvement choices but are rather considered important in a person's life. In today's world, consumers want full involvement as they are looking for credibility and want to be aware of different aspects of the products they intend to buy. It is difficult for companies to keep up with the demand and it is a challenge to build trust. In addition, market segmentation aims to understand consumer behavior and the supply chain needs to recognize the different groups that have similar requirements. The five segments identified when consumers choose food are: The easy customer with the least involvement, the customer who does not care, the conservative, rational and logical consumer, and the consumer who is adventurous (Bourlakis and Weightman 2004).

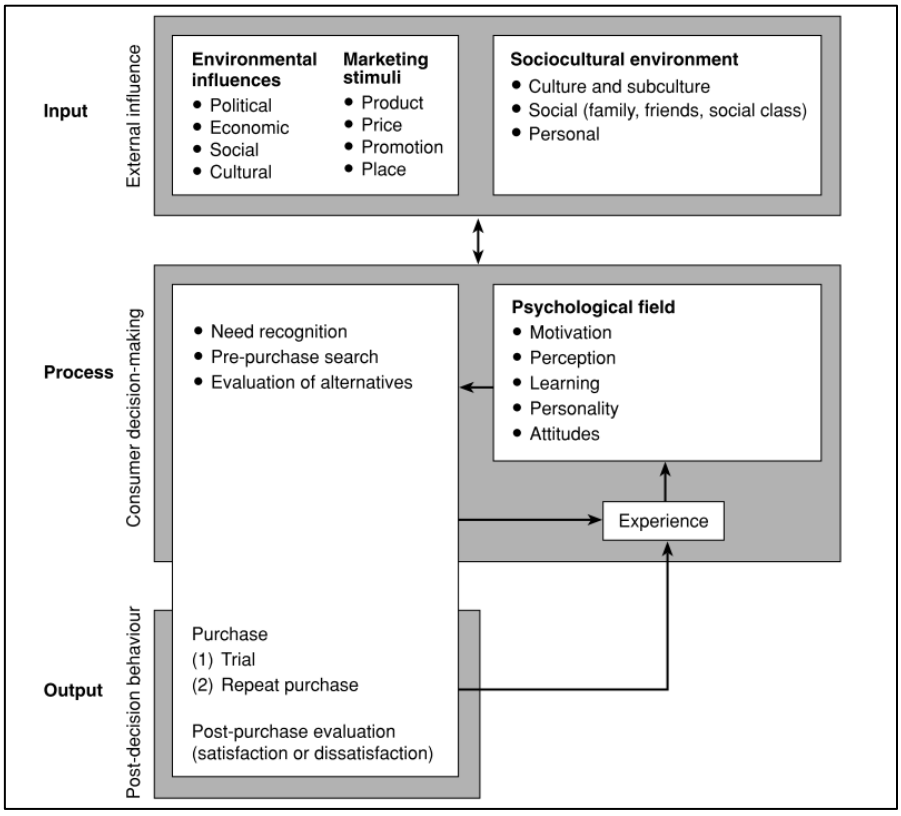


Figure 2. Consumer decision-making model (Bourlakis and Weightman 2004)

The above figure illustrates that inputs include various external factors that influence the decision-making process, and this information is passed back and forth between the processing

step and the inputs. All the aspects mentioned in the input section are processed and analyzed by the consumer and he/she decides to buy a particular product. After buying the product, the consumer reacts according to his/her satisfaction by deciding to continue buying the product or rejecting it. This feed black is again passed to the processing stage and input stage and it continues like a cycle.

Transparency is a crucial element in the food industry and stakeholders throughout the supply chain must provide customers with authentic information regarding the origin of the food, production methods, inputs, and ingredients used during the process (Paloviita 2010).

It is worth mentioning that consumers all over the world have been affected by the restrictions imposed by the government due to the global pandemic caused by the Covid-19, having limited access to diverse and nutritious food sources mainly imported from one country to another. The extraordinary situation we are currently living in has affected global food consumption and even our dietary pattern around the world. Catering service providers such as restaurants are closing down, limiting the access of people in almost all countries. These changes have pushed people to change their consumption patterns and have affected people's buying habits as nowadays most people prepare their food at home (Eftimov et al. 2020).

1.1.4 Main challenges in agri-food supply chain and their potential solutions

Farming and agriculture practices have changed in the last 50 years. People are consuming more food and the calorie intake has increased because modern technology has greatly increased productivity and decreased dependence on seasonality. Income levels are increasing every year, but food prices remain low, which continues to drive up food consumption (Kearney 2010).

The high competition focused on performance, rapid changes in technology, and globalization lead to ambiguities in the different stages of the supply chain in the food industry (Mentzer et al., 2001). In the past, most of the operations, including processing and product delivery, took place in localities. Nowadays, large companies are interested in sourcing globally and having superior facilities to produce low-cost products, which in turn could lead to instability and disruption of the entire supply network. In addition, powerful retailers, such as supermarket

chains, are putting more pressure on suppliers as they demand just-in-time deliveries (Bourlakis and Weightman 2004).

Product safety and quality are the most important elements in the agri-food industry, which require advanced traceability methods, strict measures, and control policies of the whole chain and are considered as characteristic issues in this industry. (Beske et al. 2014).

In developed societies people consume more food than necessary, changing this could be a great step as it could reduce overall food intake. In addition, replacing the consumption of red meat and dairy products with cereals and chicken may have a significant impact on environmental food consumption in Europe (Tukker et al. 2011).

Our food consumption habits have been noticeably affected by the pandemic caused by COVID -19. Food shipments and transportation have been restricted, leading to potential shortages of agricultural products such as fresh fruits and vegetables, fish, and other products with short shelf lives. The health crisis not only caused changes in production, supply, and dietary patterns around the world but also had an impact on the economic factors of our societies, including a reduction in people's incomes, which directly affects consumers' decisions when purchasing agri-food products (Eftimov et al. 2020).

Nakat and Bou-Mitri (2021) explain the disruption to the supply chain and food systems caused by the coronavirus epidemic as the industry constantly faces various challenges and strives to meet consumer demand, build trust, implement high-level safety measures, and protect the people who work for the industry. The authors also emphasize the importance of the agri-food sector, arguing that it is an essential infrastructure of today's world, along with other important sectors such as energy, healthcare, and communications, and these must continue to function undisputedly even during a pandemic (Nakat and Bou-Mitri 2021).

Reports from Centraal Bureau Voor de Statistiek (2020) indicate that 64 percent of retailers worldwide have switched supply chain activities to e-commerce and 28 percent reported shortage due to the disruption caused by the outbreak of the COVID -19 pandemic. This is a

good example of the food supply chain responding in an extraordinary situation and how internet and new technology can be used to overcome such problems.

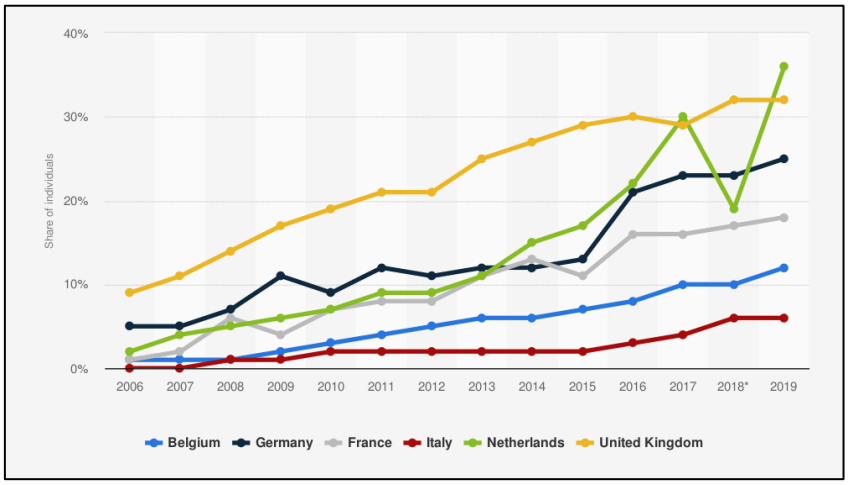


Figure 3. Share of consumers who purchased food or groceries online in selected counties in Europe (Centraal Bureau Voor de Statistiek; Eurostat; Statista 2020)

The figure above shows a significant increase in online grocery shopping. There are several trends and drivers behind the increase in the consumption of groceries or food in general. Rogus et al. (2020) explain that policy makers in the U.S. encourage online shopping because it allows certain groups of people to have better access to food. These groups include the elderly, people with disabilities, and people living in remote areas who have fewer shopping alternatives and may not have a vehicle to drive to a bigger supermarket.

Berg & Henriksson (2020) argue that the availability of smartphone technology and access to the Internet has a direct impact on online grocery shopping. Numerous organizations and companies are working to improve digitalization as people nowadays are less fearful in terms of data security and payment security. The expansion of supermarket chains and online marketplaces such as AmazonFresh makes online shopping more convenient, while people were forced to stay at home as a preventive measure due to the COVID -19 pandemic (Dannenberg et al. 2020).

Pullman and Wu (2021) argue that living through such anomalies caused by the health crisis made the whole world look at things from a different perspective and find alternative ways to help deal with such events more effectively. Eating healthy, reducing meat consumption,

improving safety guidelines, and supporting local food systems can lead to structural and fundamental changes when societies act collectively. People around the world have realized the importance of short supply chains based on local and regional agriculture. These changes could lead to positive outcomes after the pandemic, as the need to develop a sustainable food system becomes more crucial.

There are various measures and ways that could address the major problems associated with the agricultural sector and the food industry. Joining or forming cooperatives and associations by farmers to use resources efficiently, contract farming, developing market and marketing infrastructure for agri-food products, implementing policies and laws in favor of the environment, investing in modern storage and warehousing facilities to reduce wastage, building efficient processing centers, development of transport facilities especially in rural areas, addressing power and energy shortages, promotion of renewable energy such as solar and wind energy, and provision of financial support by banks are the major measures that could help the agricultural and food sector of a country, especially in developing countries, to recover and function effectively. (Ganesh Kumar et al. 2017).

1.2 Innovations in agri-food supply chain

Before examining the different viewpoints regarding innovation in the agri-food industry, it would be better to understand how terms such as innovation and invention are defined in this industry. Arlbjørn et al (2011) describe that innovation could be the discovery of a novel production method, the creation of a new product, the launching of a new product, the search for new raw materials, the execution of a new organizational model and even opening a new market. In addition, the author also illustrates how innovation and invention are different from each other by explaining that invention is a discovery, or a new idea and originality is its main characteristic. Innovation, on the other hand, involves processes and activities aimed at realizing the ideas developed through inventions.

In the food system, innovation is defined as organizational and technological integration that encompasses the entire system from primary production through processing to manufacturing and distribution (Earle 1997). Various literature and articles examined Supply Chain

Innovations (SCI) from different perspectives. Lezoche et al (2020) explain the impact of new technological innovations on reducing uncertainty through the use of tools that help in capturing data in real-time, which also enables firms to respond abruptly to the rapidly changing supply chain. The agri-food supply chain faces two types of pressures imposed by the market: constant innovation and coordination between buyers and sellers where the innovation part involves the development of powerful information and logistics systems (Van der Vorst et al. 2007).

Beske et al.'s (2014) argument is in line with the above statements as they emphasize developing collaboration among all stakeholders of the supply chain, such as training producers and farmers with new farming techniques or even investing in sustainable agriculture, which could have a positive impact on the entire chain.

The agri-food supply chain needs to invest more in modern technologies that allow it to use better management tools, analyze data effectively and develop systems that operate automatically. In particular, the industry should take advantage of digital technologies to improve production methods, food traceability, and the entire supply chain process (Lezoche et al. 2020).

Another major issue in the food industry is product safety. Man-made aspects such as industrialization and the rapid shift from rural life to urbanization are increasing pressure on natural resources, especially land and water. With food security in mind, it is not possible to rely on the inefficient traditional methods of agriculture. Therefore, it is crucial to take serious measures against the depletion of natural resources and develop technologies and methods that are more effective to meet the increasing demand for food (Mok et al.2020).

Having a unified global digitized supply chain may not be something we achieve in the near future. However, the use of artificial intelligence (AI) as part of the digital revolution is already transforming our society, and the agri-food sector could potentially benefit from this technology as it promises sustainability and efficiency (Minnens et al. 2019).

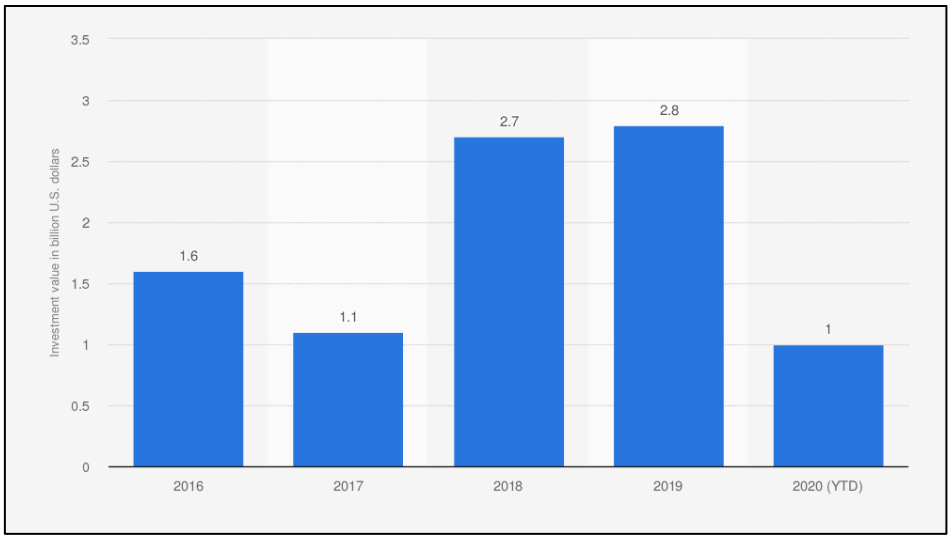


Figure 4. Value of global venture investments in food supply chain technologies (Cleantech Group; Statista 2020)

As illustrated by the graphical overview of global investment in technologies for promoting agri-food supply chain, the level of investment has increased significantly in 2019. This increase is mainly due to the complexity not only of retail channels but of the entire food supply chain (Statistica 2021).

The fourth industrial revolution has had a significant impact on all sectors and is now reaching agriculture. The development of new technologies and innovations such as Internet of Things, Big Data, Blockchain, Artificial Intelligence, Cloud Computing could improve some basic but important functions of the agri-food supply chain, such as monitoring, descriptive and predictive analytics, sensing, and decision-making processes. Bringing the agri-food sector and technological development closer to each other could potentially help replace the current inefficient and isolated system with a more developed, integrated, and intelligent system of systems (Lezoche et al. 2020).

Moreover, the application of Big Data can address the major global issues related to food safety in a sustainable and efficient manner. The implementation of Big Data does not only cover agriculture but goes beyond and into a larger domain that encompasses the entire supply chain of the agri-food sector (Wolfert et al. 2017). Below are the definitions of some technologies and tools to have a better understanding and know what they can offer:

Big data can be defined as data set that could not be handled, managed, processed, or analyzed by a traditional database due to a large amount of data that has many complex sources driven by mobile devices, social media, digital pictures, and videos, purchase records, Global Positioning System (GPS), AI and Internet of Things (IoT) (Michalik et al. 2014). Big Data can address the major global issues related to food safety in a sustainable and efficient manner and encompass the entire agri-food supply chains (Wolfert et al. 2017).

The Internet of Things (IoT) allows a wide range of connections among all sorts of devices and objects throughout the supply chain and farming that could collect a huge amount of data with real-time accessibility (Wolfert et al. 2017).

Blockchain technology would allow the creation of a transparent network that promises an agri-food value chain free of errors, redundancies, and duplications. This technology ensures the integrity of information that can be used for decision making and quick resolution of errors while creating an efficient traceability system that forms better customer relationships. (Zhao et al. (2019).

Precision agriculture (PA) is defined as a management system that is used for controlling the soil, plants, and atmosphere with the help of Information and Communication Technology (ICT). This system helps to increase productivity and efficiency, better use of resources, getting maximum yield with the minimum input and lowering the environmental impact of farming activities (Balafoutis et al. 2017). Likewise, Sim et al. (2015) utter that promoting a smart energy system throughout the agri-food supply chain could decrease GHGs emissions and environmental impacts as it recommends using clean energy technologies while producing and processing agri-food products.

In some countries, regulators and policy makers have promoted online grocery shopping as an alternative for a specific group of people that includes people with disabilities, the elderly, and those living in outer suburbs with limited access to transportation. Online shopping can help many households access nutritious food, including fresh fruits and vegetables (Rogus et al. 2020). Online purchasing of groceries and other consumer goods is growing rapidly, particularly in the United Kingdom, Germany, and France (Van Loon et al. 2015).

Research by Arlbjørn et al. (2011) shows that Supply Chain Innovations (SCI) consists of three dynamic, interactive elements that include: (1) supply chain business processes, which are defined as a framework with a calculated set of activities aimed at producing a specific output for a specific customer, (2) supply chain technology, which can be implemented alone or in combination with preexisting technologies and can even be mixed with the other two elements of SCI, (3) supply chain network structure, is the third element that focuses on the vertical and horizontal network structure of a company and its partners. The following table shows the interrelated contents of all three elements in SCI.

Table 1. Examples of content elements of SCI (Arlbjørn et al. 2011)

Supply chain business processes	Supply chain technology	Supply chain network structure
Customer relationship management	Global positioning systems (GPS)	In- and outsourcing
Customer service management	Bar coding	Partnership
Demand management	Radio frequency identification (RFID)	Collaboration
Order fulfillment	Pick-by-voice technology	Distribution channels
Manufacturing flow management	Electronic data interchange (EDI)	Type of links to supply chain actors
Supplier relationship management	Advanced planning systems (APS)	Third-party logistics providers
Product development	Warehouse management systems (WMS)	Fourth-party logistics providers
Return management	Enterprise resource planning (ERP)	Joint ventures
	Manufacturing execution system (MES)	Complexity in supply
	Product life cycle management (PLM)	
	Business intelligence	
	Internet	
	E-auctions	

In addition to these innovations and new technologies, another relevant issue is the impact of e-commerce on the supply chain of agri-food products. Nowadays, the way we acquire food is changing as more and more people are getting used to ordering various goods online, including groceries and many other basic products that we used to buy in a local store or supermarket. The recent health crisis caused by COVID -19 has boosted e-commerce which included buying groceries, while many countries introduced strict restrictions on people's movement as a precautionary measure to control the spread of the virus among the population. Some people ordered food online because they simply did not want to go to crowded supermarkets and expose themselves to the contagious and deadly virus. These extraordinary circumstances and people's changing habits are forcing the food supply chain to restructure as e-commerce continues to grow.

1.3 The efficiency of the agri-food supply chain and its relationship with the environment

1.3.1 Operational inefficiencies of supply chain

This part deals with the related aspects and the relationship between the efficiency of the agri-food supply chain and the environment. Various authors addressed these issues and discussed them from different points of view, including the impact of the use of certain technologies, issues related to management, legislation, the role of stakeholders, etc.

There are many different perspectives on what causes operational inefficiency and how to deal with it. Operational inefficiency is characterized as a phenomenon that can be caused by a variety of operational challenges such as a lack of control, inexperienced labor, and ambiguous and vague standards, all of which can increase production costs (Zhang et al, 2016). To begin, it's important to note that rising environmental awareness and concern are forcing all parties concerned, including policymakers and agricultural organizations, to build sustainable supply chains with the lowest operational inefficiencies possible. (Allaoui, et al, 2018).

Invernizzi et al. (2018) suggest an approach with a five-step framework to overcome operational inefficiencies. The five steps include: comprehension of the context, gathering the data, validating the information, analyzing and creating the current state, and eventually identifying the inefficiencies. This method can be useful in providing clear insight and analyzing the current state via improvement objectives.

A complex network of various stakeholders including processors, suppliers, distributer can be beneficial if the inventory is effectively managed in all stages of the supply chain that could lead to reducing the operational inefficiencies and eventually provision of high-quality products to the consumers. (Lee and Billington, 1992*)*. Moreover, inefficiencies can be problematic during operational processes that could harm the environment and it also limits a companies ability to benefit and create higher value (Mosovsky et al, 2000).

Many experts and public policy activists are approving the idea of eliminating intermediates to raise the income of growers and farmers alongside productivity improvement and diversity and

providing products at a lower price to the end customer which could, in turn, lead to enhancing financial value without any modification of the product (Roche 2019).

A centralized environment, a high number of stakeholders, pressure from legislators, existing complexity in a sector, limited financial resources, communication issues, lack of knowledge about supply chain management, poor waste management are the main contributors to the operational inefficiencies in a supply chain. These issues could be the result of both a structure of a system and how a system is managed (Papalexi et al. 2020)

In the agri-food supply chain, reducing food wastages, extending the lifetime of raw material that is not used and resource recovery is essential to address and deal with operational inefficiencies. Resolving these issues can lead to improving operational inefficiencies of the whole production process by fully optimizing the resources and avoiding wastes (Krishnan et al, 2020).

1.3.2 Agri-food supply chain and environment

The CO_2 produced by the agri-food supply chain is roughly 13.7 billion metric tons which makes 26 percent of GHG emission on a global scale. Food production contributes to the depletion of natural resources, negatively affecting ecological resilience and biodiversity loss. The highest amount of pollution comes from the farms that account for 61% (Poore and Nemecek 2018). Carlsson-Kanyama (2003) on the other hand, says that food consumption is creating the most pollution in our day-to-day life. Practicing sustainable methods for producing food in all stages is crucial as it can help in dealing with climate change issues. However, Krishnan et al (2020) pointed out that there are very few studies that focus on identifying operational and resource inefficiencies in FSC that use the results of environmental impact analysis to create a more sustainable model.

Environmental protection is considered the most important matter in the sustainable development of the world in recent decades. Considering the importance of sustainability, manufacturers all over the world have developed and improved new methods to produce products that are environmentally friendly and biodegradable. These efforts require the company to consider a number of changes related to production and other related activities that

could positively affect the companies performance and profitability. Energy effectiveness and lower operational inefficiency are the most important factors to achieve goals such as global sustainability (Zhang et al. 2016).

Different companies pursue certain financial goals so that a company can grow and continue its activities. However, the achievement of these goals should not be at the expense of social responsibility and risk to the environment. In addition, it is necessary to create consistent, long-term cooperation between all stakeholders in the agri-food supply chain, but it is not always easy to get all parties to agree. (Dania et al. 2016).

Van der Vorst et al. (2007) noted that in Western countries a "license to produce and deliver" is obtained by businesses, and this license conveys the associated information about how the product is produced and by what means it is delivered. People in western society are concerned about these details and do not accept products that cause high levels of pollution, involve underage labor, and other dubious issues as such.

Sustainable production practices and methods are defined as using the minimum amount of material for the highest amount of yield and avoiding pollution and reducing waste on the supply side. These practices include environmental management systems, use of clean technologies, environmental protection, eco-efficiency, and waste management (Yakovleva and Flynn 2004). Another important aspect that has a great impact on the environment is the type of technology used by companies. There is a high dependency between the technology chosen by a company and its impact on environmental economic efficiency. (Aparicio et al 2020).

Sustainability can be achieved if consumers, who are considered the key stakeholders in the agri-food supply chain, play an active role by making sustainable consumption choices and changing their dietary habits. This consumer contribution can start with buying locally produced fruits and vegetables instead of meat and dairy products imported from abroad (Carlsson-Kanyama 2003). Tukker et al.'s (2011) statement support this argument as he says, "*Meat and dairy are among the highest contributors to environmental impacts from food consumption. A healthier diet might have less environmental impacts".*

A shift towards the consumption of plant-based alternatives and change in eating habits could be a desirable objective to achieve. Furthermore, vegan, and vegetarian diets could help preserve

the natural environmental resources that are consistently depleting while promising a significant reduction of hunger in developing and poor countries. Developed nations need to invest in educating people and spreading awareness regarding people's attitudes towards consumption habits as it is also among the objectives of the ' EU program in favor of the environment and sustainable development'. (Baroni et al. 2007).

1.4 Veganism and the supply chain of vegan products in Germany

This part of the thesis discusses how the agri-food supply chain in Germany is changing due to the rapid changes of the food consumption landscape, as the number of vegans and vegetarians increases. First, however, the vegan product and common diets are defined and represented in the table below to understand which products are included or excluded in certain diets.
The European Vegetarian Union's (V-Label) (2018) definition of vegan products is as follows:

> *"Products are considered vegan if they are not products of animal origin and in which, at no stage of production and processing, use has been made of or the product has been supplemented with ingredients (including additives, carriers, aromas, fragrances, flavourings and enzymes) or processing aids or substances which are not additives but are used in the same way and with the same purpose as processing aids in either processed or unprocessed form that are of animal origin."*

Table 2. Type and definition of diets (Adapted from Dagnelie and Mariotti 2017; Weder et al. 2019; The Vegan Society 2020)

Definition of Diets	
Vegan	Veganism is defined as a lifestyle beyond diet. People who are following this lifestyle not only avoid animal food, dairy products, but they excluded consuming cosmetics, clothes, and even furniture that are derived from animals.
Omnivorous	People following this diet eat meat, dairy products, and vegetables, etc.

Definition of Diets	
Ovolactovegetarian	Are following a diet that includes dairy products, eggs but no meat, seafood including fish, shrimps, etc.
Lactovegetarian	As ovolactovegetarian, but dairy products are included but they do not eat eggs.
Ovovegetarian:	Similar to ovolactovegetarian but they consume eggs and no dairy.
Pescetarian/pesco-vegetarian	This category includes fish and other seafood in their diet, but they do not consume meat.
Flexitarian	People following this diet are majorly dependent on vegetables and fruits and seldomly they include meat and fish in their diet.
Reducetarian	Takes a further step and even reduces the consumption of animal products including dairy products.

Germany is the most important market for foreign products in Europe, with over 83 million wealthy consumers. This makes this country the third largest exporter and the second largest importer of agricultural products in the world. Germany is considered a net importer of main food products and there are many fast-food restaurant chains that offer vegan or vegetarian alternatives to their customers, as 3.2 percent of the population now identifies as vegan. The number of vegans has doubled in the last four years from 1.3 million people in 2016 to 2.6 million in 2020 and continues to rise (Bielinska et al. 2020; Starostinetskaya, A. 2020)

Different motives such as ethical reasons, environmental protection, and health concerns are leading to a significant increase in demand for vegan products and a vegan diet among consumers in developed countries. Moreover, vegetarianism and veganism are a means or a way of self-identification for certain people. A 2014 study conducted in seven vegan supermarkets in Germany shows that consumer motivations are driven by concern for animals (89.75%), health (69.3%), and the environment (46.8%) reported by participants. Even though vegan consumers represent only a small percentage of the total population of countries, this small percentage can have a significant impact on the consumption patterns of the agri-food industry (Radnitz et al. 2015; Janssen et al. 2016; Simons et al. 2021).

Figure 5. Main motives behind choosing a vegan or vegetarian lifestyle (V-Label 2021)

The motives behind purchasing biocyclic-vegan products differ among consumers. Some buy these products to support biocyclic-vegan agriculture[1] practice, other consumption motives are health, environmental, and ethical reasons Meanwhile, experts indicate that ethical reasons have the highest importance, followed by health and environmental motives (Jürkenbeck et al. 2019).

Nearly a quarter of Green House Gas (GHG) emissions are generated by activities related to the agricultural sector and land use, and livestock production accounts for more than half of them. Therefore, changing diets can play an important role in reducing pollution generated by the agri-food supply system (Bryngelsson et al. 2017). Studies by Baroni et al. (2007) and Tukker et al. (2011) also suggest that a plant-based diet and avoidance of dairy products are better for the environment compared to a meat-based diet, as rapid population growth and increase in income levels lead to higher consumption of meat and dairy products.

Looking at these figures raises the important question of which products are most in-demand as meat substitutes. Answering this question will help suppliers better understand market trends and respond effectively to customer demand. A study conducted by Veganz (2020), a vegan supermarket chain in Germany, found that 50.1% of the vegan population wants more vegan sausages, cheeses, and snacks. In addition, 39.4% of the vegans in Germany demand more baked goods.

[1] Biocyclic-vegan agriculture is entirely organic and plant-based farming practice. It includes no animal slaughter and commercial livestock farming and it uses non-animal inputs while focusing on promoting soil quality, biodiversity (Biocyclic Vegan Agriculture 2021).

Baroni et al. (2007) analyzed the environmental impact of different dietary patterns using a system that assigns a numerical value represented in points (Pt). The higher the score, the greater the negative impact on the environment. Upon completion of the analysis, the animal product-based diet was found to have the highest score, while the vegan diet had the lowest.

Change in eating habits of people is influencing the market to find new ways to meet the trending demand as the percentage of meat substitutes products sales have been growing by 451% between 2013 and 2017 in the European market. The predictions indicate that by 2022 the value of this market will be around six billion euros (Vou 2019). In Germany people are showing more and more interest in vegetarian and vegan products as 35 percent of the population consider access to these products as "very important" and 63 percent of the entire population are adopting a lifestyle that includes decreasing consumption of meat that makes the country one of the biggest vegetarian market in the world (Bielinska et al. 2020).

There are numerous studies, researches, and surveys that prove that Germany is a country that is moving towards significant changes in dietary patterns and eating habits as they try to reduce their consumption of animal products and instead switch to locally produced products mainly vegetables and fresh fruits that have a lower carbon footprint and are healthier. These shifts are causing major changes in the agri-food supply chain. As a result, suppliers are taking steps to keep up with the growing demand for vegan products, mainly by introducing new brands and new products that replace meat and other dairy products. Germany has the highest share of new vegan product launches, as shown in the graph below.

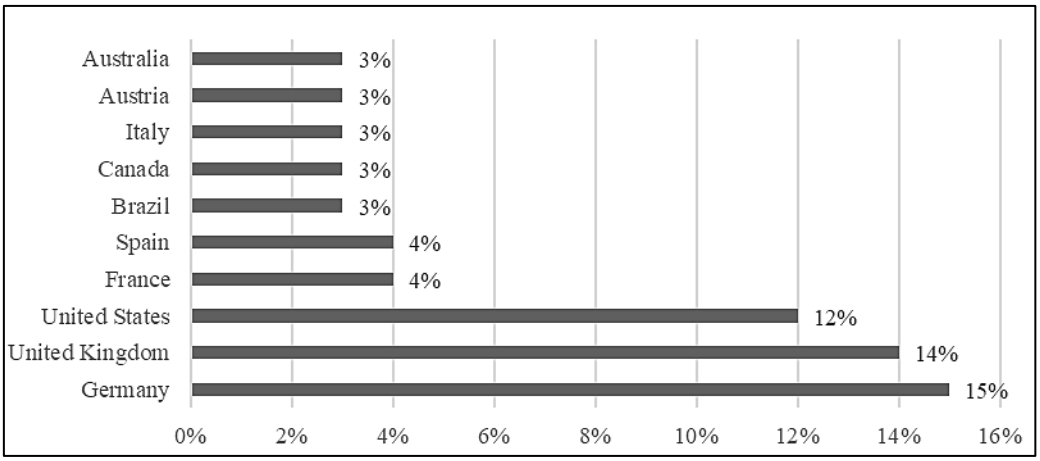


Figure 6. New vegan product launches in 2018 (Worldwide; Mintel; 2018)

Not only Germany, but all European countries will potentially react by exporting meat and dairy products to other nations, especially developing countries, while losing their domestic market over time (Tukker et al. 2011).

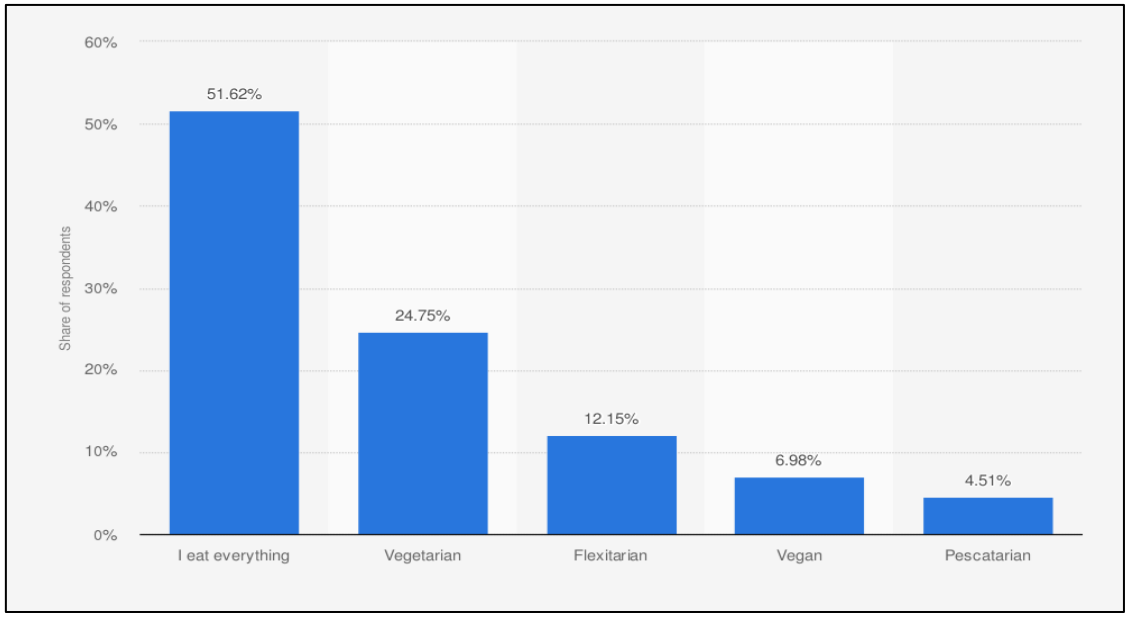


Figure 7. Percentage of people describing their diet in Germany (Kitchen Stories; Statista 2019)

The above figure shows how people in Germany describe their diet and it seems that about 50 percent of the population does not eat meat or rarely consumes meat, which is a big clue for the food industry in Germany and explains the fact that not as much meat is consumed as in the past. In a survey from Kitchen Stories (2020) published by Statista, people's interest in the vegan diet as a food trend in Germany was third with 17.48% after Low Carb and Low Sugar with 33.1% and 35.37% respectively, followed by High Protein (13.81%) and High Fiber (10.24%). People's interest in a vegan diet is significant and explains the increasing demand for meat and dairy substitutes.

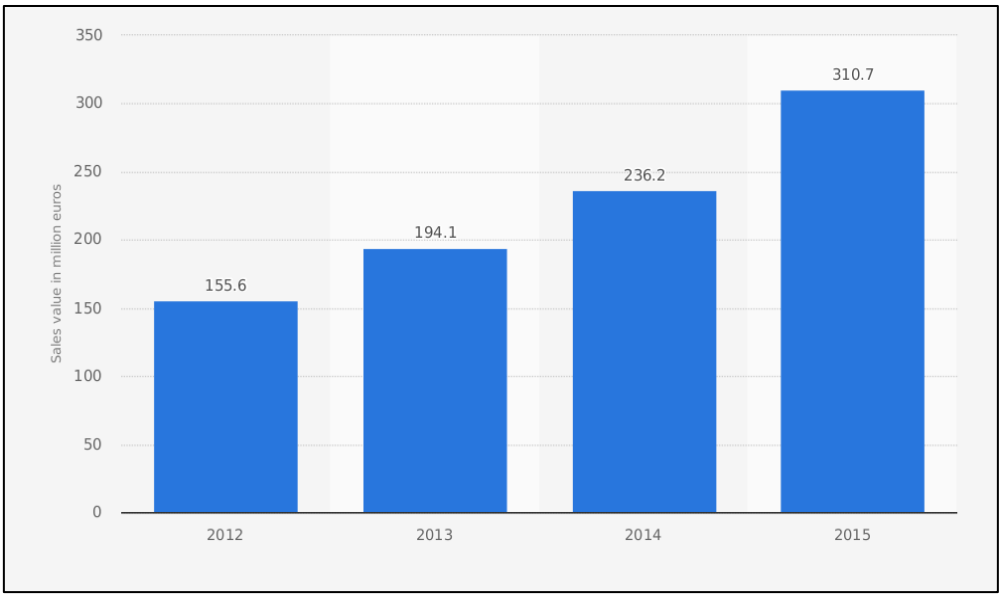


Figure 8. Sales value of plant-based spreads and meat substitutes in Germany (Markenartikel Magazin; Statista 2018)

The above figures show an increase in sales of plant-based products and meat substitutes, which doubled from €155.6 million in 2012 to €310.7 million in 2015. Moreover, the market size of meat substitutes is also growing in European countries, with Germany ranking second after the United Kingdom. The value of the meat substitutes market size in 2019 was estimated at 200 million euros (Statista 2019).

The studies analyzed in this part of the thesis focused mainly on European countries and Germany in particular. It is clear that many developed countries are promoting a vegan supply chain and more and more people are adopting this lifestyle as a sustainable way of life. However, this does not mean that veganism is just a big trend in a developed country. A study by Niederle and Schubert (2020) shows that in Brazil, 30 million people, or 14 percent of the country's population, do not eat meat, although 60 percent of people in Brazil do not consume vegan foods because they are more expensive compared to animal products. Therefore, it is safe to say that sustainable lifestyle practices are receiving a lot of attention on a global level, both in developed and developing countries.

1.4.1 Vegan Labels

In many countries, there are no government-enforced guidelines or third party organizations responsible for certifying certain food products. Vegan labeling, labeling procedures, and guidelines vary from one organization to another (Wrenn 2011). The oldest vegan labeling was introduced in the 1970s and since then many labels have been introduced mainly in Europe, the United States, Japan, and Canada. The most recent label organization was established in 2017. Independent organizations recognized by the vegan and vegetarian community offer vegan labeling as a service where experts examine products and confirm whether or not they are vegan (About Vegan Certification, 2020). Although labeling a product as vegan only verifies the ingredients and ensures that the ingredient list is free of animal products and byproducts, it does not include the production phase. For example, a company can label a finished pumpkin soup as vegan, but the farmer who grew it used animal manure in growing the pumpkin (Juerkenbeck et al. 2019).

Recently, a number of associations such as Fairtrade and Forest Stewardship Council offer certification services that inspect not only the product itself but the entire production processes to ensure that the entire chain was free of animal activities. Other organizations involved in vegan certification are the Vegan Society's Vegan Trademark, the Certified Vegan Logo, which is based on an American non-profit organization called Vegan Action, and the V-label of the European Vegetarian Union (Beck and Ladwig 2021). In addition, certified companies can use the biocyclic-vegan label, as biocyclic-vegan guidelines of the International Federation of Organic Agriculture Movements (IFOAM) is recognized as the first global vegan organic standard (Juerkenbeck et al. 2019). The official vegan certification associations based in Europe are listed below:

Figure 9. Logos of Europe based official vegan certification associations (Vegan Official Labels 2020)

In a study by Gerke and Janssen (2017), data from 24 grocery stores for eleven product groups in Germany were analyzed, showing that there are two types of labels for vegan foods, namely third-party labels from an independent organization and producer labels. 108 products were examined and of these, 79 percent had a manufacturer label, 44 percent had a third-party label, and a total of 23 percent had both a third-party and producer label. The study also showed that the standards and evaluation processes of independent labeling organizations could be found on the Internet, but there was very little information about the labeling procedure of producers. The authors concluded that labeling practices by producers need to be more transparent, as they are not entirely consumer-friendly.

The initiator of the V-Label is the European Vegetarian Union (EVU) and it works in collaboration with many Europe-based organizations that work in the area of veganism and

vegetarianism. This organization claims that there are 30,000 products and services from about 3,500 license holding entities are carrying the V-Label on a global scale (V-Label 2021).

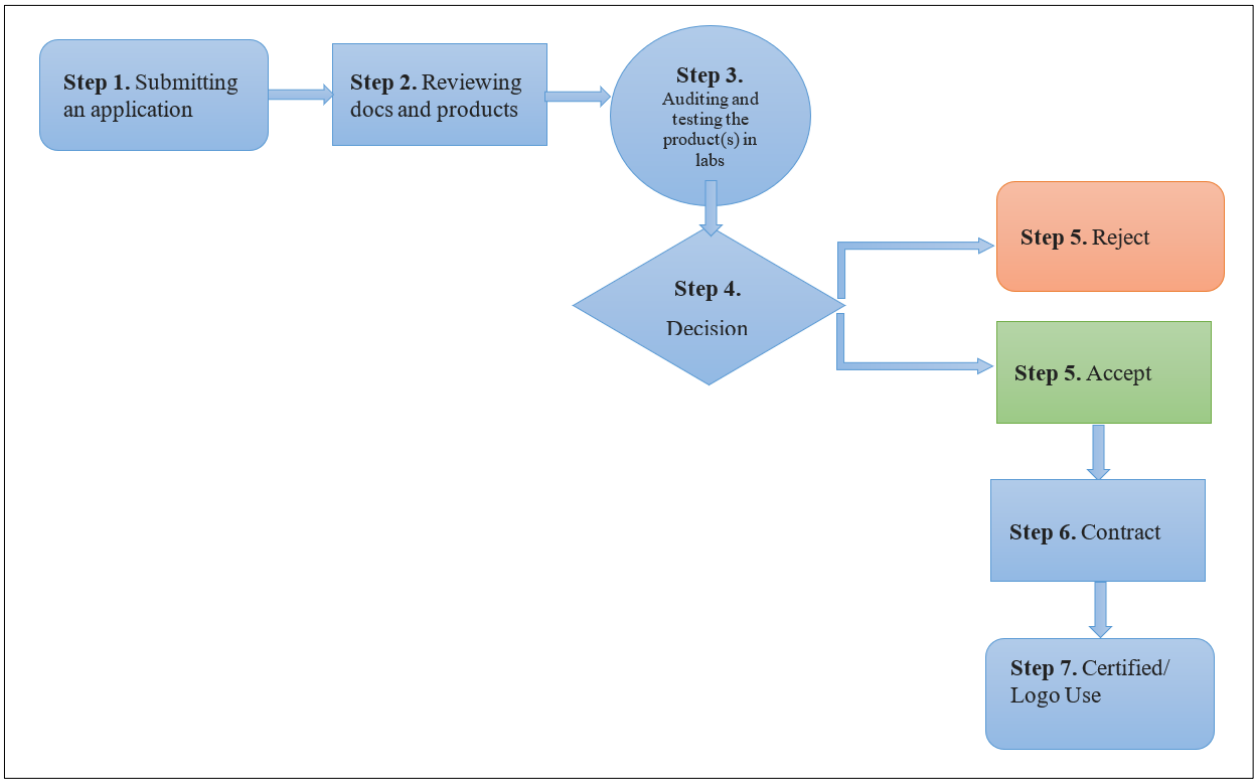


Figure 10. Vegan Certification Process (Created by the author based on information gathered from vegan.org and beveg.com)

The certification processes shown in the above figure begin with the submission of an application by the manufacturing company to the labeling or certification organization. The organization will make a series of inquiries about processes, ingredients, animal testing, and so on. After that, all documents are reviewed. The next step is to schedule the audit to examine the processes. After completing a full on-site audit and laboratory analysis, a report will be prepared. Based on the report, a decision of approval or rejection is made. After signing the contract, the product is certified, and the company can print the logo on the packaging.

Germany took further steps ahead, as they have formed legal definitions for labeling institutes to define vegan and vegetarian products.

> " *To be defined as vegan, foods must not be of animal origin or contain ingredients, processing aides, or other substances of any animal origin. Vegetarian goods have the same restrictions as vegan ones except that they may contain milk, colostrum, eggs, honey, beeswax, propolis, or wool grease" (Bielinska et al. 2020).*

As of April 2016, all actors using the term "vegan" must adhere to the above-mentioned definition of the consumerism ministers, and a company is not allowed to create its standards and guiltiness on its own to define vegan quality with it in Germany (Gerke and Janssen 2017).

1.4.2 Main challenges of vegan products supply chain

Vegetarian and vegan diets are considered healthy lifestyle as they reduce the risk of many diseases such as heart problems, blood pressure disorders, etc. However, a plant-based diet can lead to certain nutrient deficiencies and problems like bone fractures can occur if proper supplements are not taken. Therefore, vegans need to take supplements regularly that contain vitamin B-12 and D, omega-3 fatty acids, and calcium (Craig 2009).

The increasing demand for vegan foods has led to increasing pressure on the agri-food supply chain. Some of the challenges could have a direct impact on the supply chain, so they need to be addressed in a timely and effective manner. It is more or less clear that a vegan diet helps to address various issues such as environmental issues, sustainability, animal welfare, health, etc. However, the important question is whether the food supply chain is ready for the existing and future emerging challenges and opportunities?

Biocyclic- vegan agriculture is at a very early stage of the product life cycle in Europe. Therefore, not much research has been done and little is known about it (Jürkenbeck et al. 2019). COVID -19 caused problems in all sectors as movement restrictions have led to shortages of perishable agri-food products such as fish, fresh fruit, vegetables, etc. (Eftimov et al. 2020). Niederle and Schubert (2020) point out that due to the lower income of people in Brazil, more than half of the population cannot afford a vegan diet because the prices are higher than those of animal products.

Plant-based foods usually need to be transported refrigerated and require cold storage all the way from the supplier through various stages such as warehouses and stores to consumption by

the end consumer (Merchandise Warehouse (2020). This creates a huge carbon footprint for many of the heavily consumed products, especially if the products are imported from long distances.

Furthermore, the increasing number of vegans is leading to a further increase in demand for vegan products, which in turn is having a negative impact on the animal products industry (Azrak and Charlebois 2020). Many industries are built on meat and dairy production. Stopping all of these sectors at once will cause mass unemployment and could be drastic to the economies of many countries.

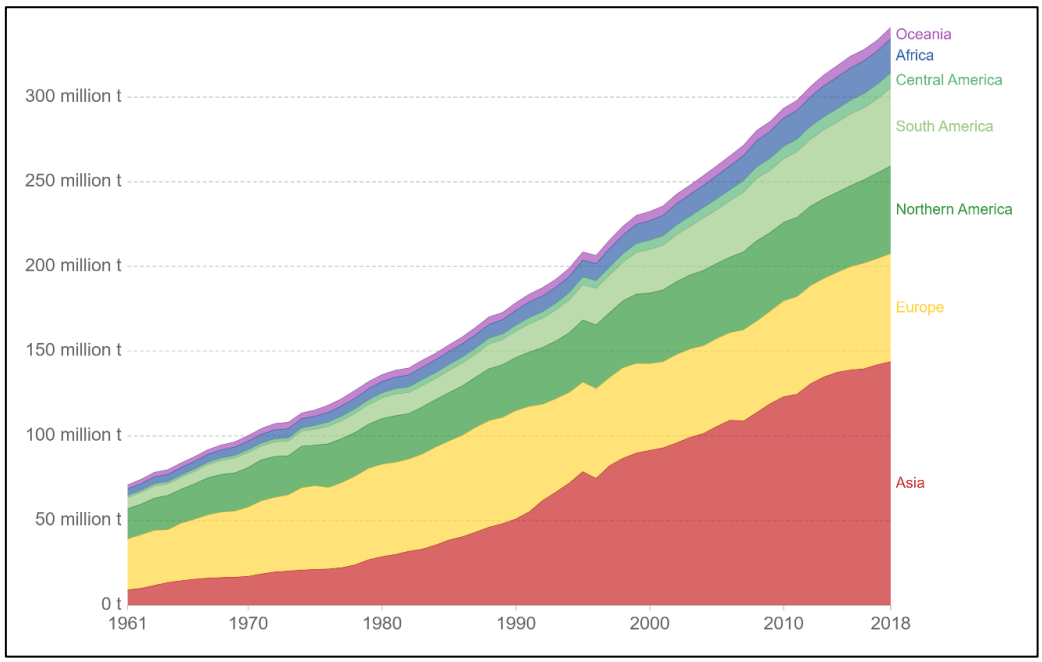


Figure 11. Global meat production (UN Food and Agriculture Organization (FAO))

The graph shows that the production of meat has quadrupled in the last 50 years, while the demand for Animal-Source Food (ASF) is increasing. This figure shows that a significant number of people depend on the meat industry, which includes farmers, producers, processors, transporters, etc., and most importantly, consumers. Therefore, a negative impact on the meat industry can drastically affect everyone involved in this industry.

It is a fact that the number of vegans is growing but animal-based products are still widely produced and consumed food items in Germany. The following chart represents the production value of food products in percentage by segment:

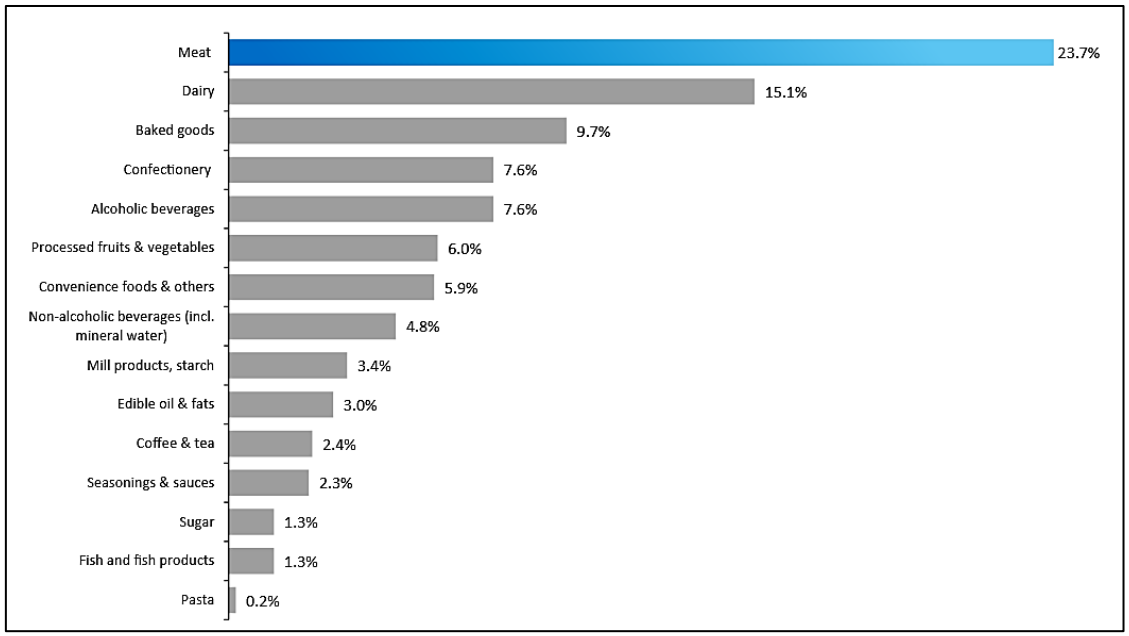


Figure 12. Production value of German food and Beverage industry by segment in 2018 (in percent) (Federation of German Food and Drink Industries; Germany Trade and Invest 2020)

The graphical representation illustrates the importance of meat and dairy products in the food supply chain of the German market where the production value of meat and dairy products are 23.7 % and 15.1 percent respectively that is significantly higher than the plant-based products listed in the graph.

Some of the vegan products, which are mainly in demand by people who follow a plant-based diet, cause serious problems. Kim (2018) noted that avocado, which used to be a seasonal fruit on the West Coast, is now an everyday meal for some people. The overproduction of avocados leads to ecosystem disruption, deforestation, and climate change issues. Growing I kilogram of avocado requires 1000 liters of water, compared to broccoli, which only requires about 45 liters. Farmers in South America cut down pine trees and replace them with avocados, directing water from far away areas to avocado farms, leaving local species without water, and cause water shortages in adjacent regions - these are the main problems caused by avocado production.

Table 3. Opposing arguments of veganism and its supply chain

Author(s)/ Organization(s)	Opposing arguments and challenges
Gerke and Janssen (2017)	Lack of transparency in labeling vegan products.
Jürkenbeck et al. (2019)	Limited knowledge and transparency regarding the producing cycle of vegan agriculture.
Eftimov et al. (2020)	Limitation of movement makes the supply of perishable products difficult in extraordinary situations such as the outbreak of COVID-19.
Niederle and Schubert (2020)	Few people can afford vegan products due to the higher prices compared to animal-based products.
CB Insights (2020)	Some meat alternative such as lab-grown meat does not sound appealing to everyone, and consumers are psychological not be ready to try it as they may prefer traditional meat.
Simons et al. (2021)	Surveys show that there is no difference in the intake of ice cream, alcohol, sweets, and fruits of vegetarians and omnivores. Hence, plant-based diets are not necessarily associated with a healthier lifestyle.
Craig (2009)	People following vegan diets may face potential nutritional shortfalls.
Merchandise Warehouse (2020)	Refrigerated transportation of plant-based products is not environmentally friendly.
Mottet et al. (2017)	The positive contributions of livestock production are income generation at household and national levels, direct provision of macro- and micronutrients, and supply of manure for agricultural activities. In addition, 86% of the world's livestock feeds consist of materials that humans do not eat. Livestock production uses marginal land and

Author(s)/ Organization(s)	Opposing arguments and challenges
	transforms non-edible grasses and agricultural by-products into protein-rich food.

The search for a solution, the discovery of the roots and causes of a problem always requires a multi-perspective view. The above table presents a different perspective on the matter discussed at length in this chapter. The aspects highlighted are undeniable, and they all have huge implications for the entire agri-food supply chain.

1.4.3 Measures for improving the supply chain of vegan products

From an information and Communication Technology (ICT) perspective, the vegan food supply chain can be improved in several ways. The creation of label and ingredient transparency tools, such as HappyCow, CodeCheck, and VanillaBean, help to build trust and encourage customers to try new products without hesitation. The development of platforms to raise awareness of the value of products and the reality consumed could potentially reduce food waste, as farmers and producers will avoid oversupply and shortages (Lawo et al. 2020).

One of the main motives of opting vegan diet is environmental reasons as suggested by some researchers discussed earlier in this chapter. Vegan customers are usually well informed and pay attention to the environmental friendliness of goods when buying them. Therefore, locally sourced food can attract the attention of vegan consumers. Zwart and Wertheim-Heck (2021) argue that a globalized food supply chain is often seen as unsustainable due to the importation of food from overseas, various means of transportation that transport the food from thousands of miles away causing a huge carbon footprint. Therefore, a (re)localization of food sourcing is proposed that includes farmers markets and Community Supported Agriculture (CSA) as Alternative Food Networks (AFNs). In addition, supermarket chains such as Walmart. Tesco and Carrefour offer local products as part of their sustainability initiatives.

One of the main issues with vegetables and fruits that vegans and vegetarians or mainly relying on is that they have a short shelf life, making them hard to preserve. A solution to this issue could be preservation by freezing the products as Rahman and Velez-Ruiz (1999) argue that the

shelf life of perishable products can be extended considerably by freezing. Freezing causes alteration in the physical state of ingredients as the water turns into ice. In low temperatures for instance -18° C enzymic and non-enzymic changes slow down and microbial growth halts that increase the durability of the products. Startups and companies that are engaged with the production of plant-based products should benefit from this technology as it contributes to overcoming one of the significant issues.

The promotion of veganism must be done through means of vegan education, which includes awareness of the industry's consumption and labeling practices. Furthermore, tactics such as protests, and demonstrations may be insignificant as they only single out issues and give more importance to one issue compared to another in the agri-food sector. Instead, a more effective way is to address these issues collectively by clearly proclaiming that all types of animal use are intolerable and that this must be reflected in the policies and guidelines of legal entities. (Wrenn 2011).

Guignard (2019) points out that the vegan supply chain can function effectively and efficiently if it addresses issues such as traceability and sustainability, collaboration among different stakeholders, investment in innovative technology, collaboration among various functions, and education.

Encouraging people to a plant-based diet is a long-term shift that needs to start small. To encourage people and gain their support, start with a subtle approach such as the flexitarian diet, as it involves a vegetarian diet alongside a small number of animal foods. This method can lead to greater public involvement without alienating them. Fundamental changes such as changing the eating habits of the entire planet cannot happen overnight and stopping the production of meat all at once is not a viable option as it could significantly disrupt the food supply chain on a global scale (Martin 2020). Furthermore, the adoption of clean technologies by various members of the supply chain is an important step towards sustainability and pollution reduction and is followed by a tax cut by the government as a way to encourage companies to adopt environmentally friendly technologies (Shi et al. 2019).

Going vegan is not an affordable or easily accessible option for many people. In many countries around the world, people can barely afford primary food items and are simply unable to make

ethical and environmentally conscious food choices (Ann 2020). Therefore, issues such as food insecurity and inequality need to be addressed on a global scale. For veganism to become more widespread, it is important to find ways to make vegan products affordable and accessible not only to middle- and upper-class people but also to the underprivileged class of society.

1.4.4 Vegan supply chain map

The supply chain of vegan products has the same stakeholders as any other ordinary food supply chain. As shown in the figure below, the agri-food supply chain usually starts with input companies that supply farmers with seeds, fertilizers, animal health and nutrition, and so on. Farmers' produce (grains, meat, and dairy products) can be used as inputs by traders and food companies and even sold directly to consumers; traders collect farmers' produce and sell it to food companies and from there it moves to the retailer that includes supermarkets and stores and at the end consumer buys the product from retailers, completing the supply chain cycle.

However, there is a significant difference between the supply chains for vegan and non-vegan foods. In the case of vegan products, farmers do not supply milk or meat; instead, they supply processing companies with plant-based raw materials such as oats, milk, and rice, which are then processed into vegan milk, cheese, meat, etc. Furthermore, the difference between a vegan supply chain and a conventional animal-based food supply chain is how they impact the environment, resource use, sourcing methods, ethical aspects, etc.

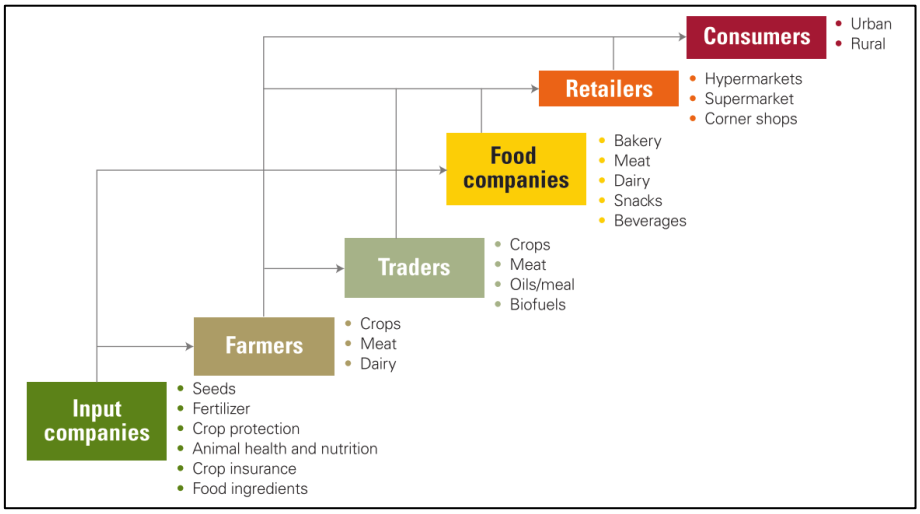


Figure 13. The supply chain of agri-food products (KPMG 2013)

As an example, oat milk will be compared with cow milk to understand the differences between the supply chain of vegan products and non-vegan products and also compare other related aspects such as the environmental impact of producing the two types of milk.

Table 4. Differences in the supply chains of oat milk and cow milk (Statista 2020; Haake 2021; Settembre 2019)

Comparison Criteria	Oat milk supply chain	Cow milk supply chain
Farms	Crop farms	Crop Farms, livestock farms, Dairy farms
Processors	The company itself is processing the oat acquired from the farms	Any type of food processing company
Distribution	Encourages local and short supply chain	Worldwide and long supply chain
Transportation	Using different means depending on the destination.	Using different means depending on the destination.
Retailors	Vegan supermarkets and cafeteria, ordinary supermarkets, local stores	Ordinary supermarkets, local stores, farmers, etc.
Target consumers	Vegans, vegetarians, omnivores	Omnivores and vegetarians
Land use	0.8 m^2 per liter.	9 m^2 per liter.
GHG Emission	0.9 Kgs of CO_2 per liter.	3.2 Kgs of CO_2 per liter
Prices	The price of oat milk is almost 2.5 times higher than dairy milk.	Cow milk is almost 2.5 times cheaper than oat milk
Water Use	To produce one liter of oat milk needs about 48 liters of water.	To produce one liter of cow's milk it needs about 628 liters of water.

As an example, the supply chain of Oatly, a well-known Swedish company producing plant-based milk, is presented. The company was founded in the 1990s and this brand is available in more than 20 countries in Europe and Asia. The infographic below shows the process of oat milk production and consists of farmers, manufacturing process, packaging, transportation, retailers, and consumers. Information about the different stages of manufacturing the product is also included.

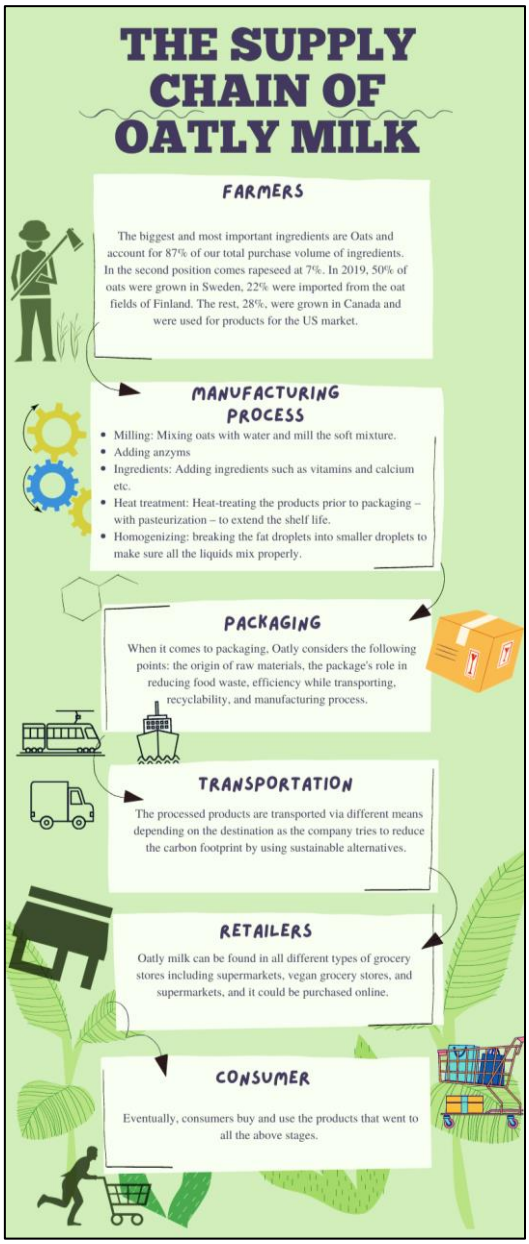


Figure 14. The supply chain of Oatly milk (Created by the author from oatly.com)

Switching to a plant-based diet not only helps overcome the ethical problems associated with eating animal products, but also goes a long way toward solving the environmental problems caused by raising livestock. The annual breeding of billions of animals around the world produces a huge amount of methane gas, which is one of the main causes of climate change. In many countries, people are destroying the natural habitats of certain areas to grow crops that are used to feed animals, resulting in the loss of native plants and animals. More importantly, these changes threaten honeybees, which are very valuable pollinators and without which one-third of the existing food supply chain will be lost (Ettinger 2018). This shows how the animal-based food supply chain is negatively impacting the environment, which could have drastic consequences.

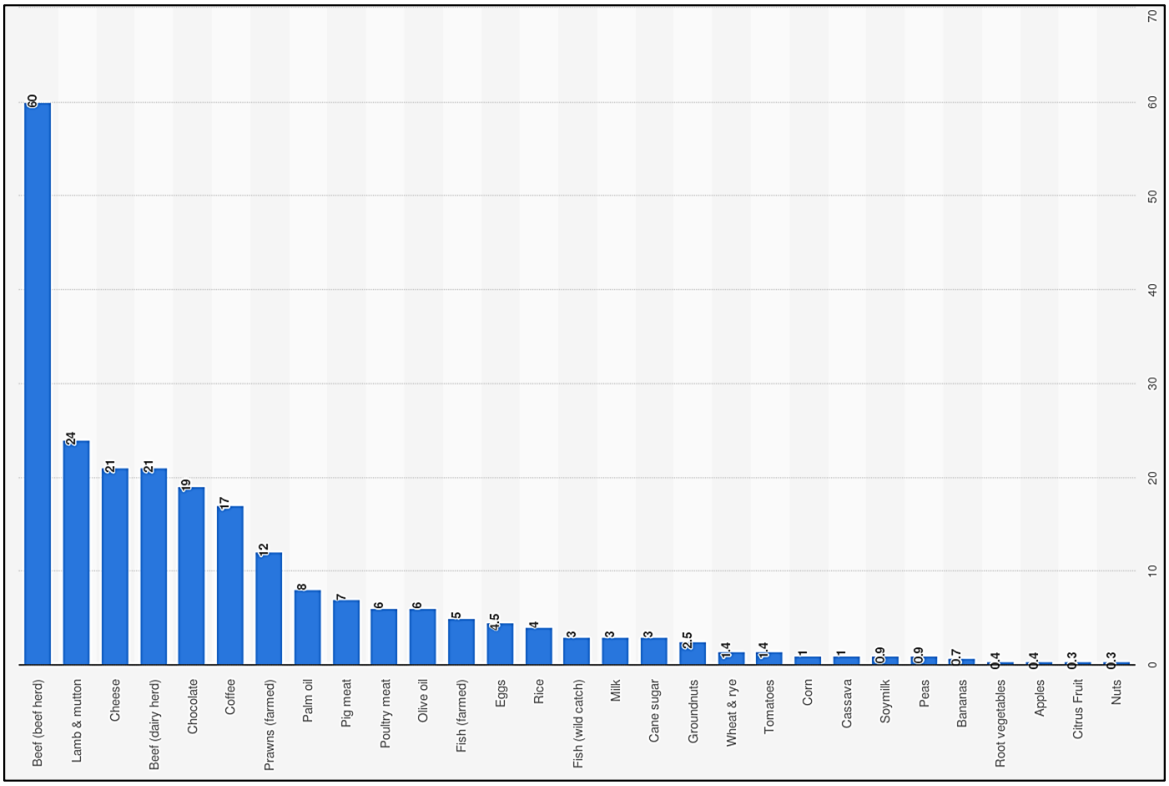


Figure 15. The global carbon footprint of the food supply chain by product in 2018 *(in kilograms of carbon dioxide per kilogram)* (VOX; Statista 2020)

The above data represents 119 countries and data from more than 38,000 commercial farms. It clearly shows a substantial difference between the amount of carbon dioxide produced from one

kilogram of animal-based products like meat compared to plant-based products such as fruits and vegetables.

It is important to understand how the current transformation in the agri-food industry works. Negative outcomes associated with industrialization need to be addressed, especially the failures of the livestock sector. In the last century, the motto of the food industry was bigger, faster, and cheaper; factory farming products are based on these mottos, but that does not mean they are better. The main problems associated with this practice are the depletion of natural resources, the mistreatment of animals, the increasing number of people with obesity, stroke, cancer, and other deadly diseases (Ettinger 2018).

The literature review contributed to this study in several ways: First, the literature highlighted the importance of the agri-food supply chain, addressing related issues such as management, sustainability, and environmental issues. Secondly, the food industry is very consumer-driven, hence, various trends and new methods in dealing with consumer demand were thoroughly covered by reviewing various academic sources and literature. Thirdly, the increasing demand for vegan products in the agri-food supply chain was highlighted and how the supply chain needs to respond to meet the demand in a sustainable manner.

2. SURVEY ON VEGAN CONSUMPTION TRENDS AND THEIR IMPACT ON FOOD SUPPLY CHAIN IN GERMANY

2.1 RESEARCH METHODOLOGY

2.1.1 Data collection

The data used in this paper was collected through both a secondary research approach and primary data collection. The secondary data was obtained from numerous academic articles, books, online newspapers, blogs, and websites. The literature review mainly uses academic articles retrieved from Google Scholar, ScienceDirect, ResearchGate, Web of Science, and Ebscohost. Lists of keywords and subject terms for each topic were created and searched using basic, advanced, Boolean operators, and phrase search methods that facilitated access to targeted and related information. The secondary data is presented in the literature review and integrated into the empirical part.

Quantitative data for the research was collected through an online survey created at Google Forms using a convenience survey approach. This is particularly suitable for obtaining an overall picture of the opinions of a large group of people with regional independence. The increasing influence of mobile internet-capable devices such as tablets, smartphones, etc. makes online surveys more attractive as respondents have the flexibility to access the online survey regardless of time or location. The questionnaire had two sections, the first section consisted of 4 demographic questions and the second section contained 10 questions including multiple-choice questions, Likert scale questions, and some closed-ended questions.

The survey aimed to study the main stakeholder of the AFSC which is the consumer as pointed out by many studies in the literature review (Asp 1999; Bourlakis and Weightman 2004; Maloni and Brown 2006; Gallardo 2015) and the ultimate goal of the supply chain is to provide value for consumers and meet their demands. The survey results are integrated with secondary sources to discuss the impact of vegan trends on the AFSC.

Initially, the survey was distributed by contacting friends from Germany through social media platforms such as Facebook, Instagram, and Whatsapp. Everyone was asked to share the link to the questionnaire with their family members and friends in order to get a high number of

responses. To encourage respondents to share the survey further, a short message was left next to the thank you note: "I would be very happy if you could forward this link to your vegan friends and/or relatives who are from Germany to get more responses", which was helpful to get more responses.

The next step was to search Facebook for groups and pages that have a vegan audience in Germany. The most effective way was to search for the names of major cities plus the word "vegan", which helped to find many groups in different cities in Germany. Requests were sent out to join groups, as most groups were closed and only members could post and share content. After joining some groups, the link to the survey was posted, along with a short message asking members of the group to take the survey. The survey was open for responses (04/24/2021) through (05/05/2021). 435 responses were collected by the end of day 12 and responses to the question were collected anonymously.

2.1.2 Data analysis and description of the respondents

This analysis is based on 435 responses to a questionnaire presented in Appendix 1. The respondents include different age categories, genders, education levels, and places of residence as shown in Appendix 2. The majority of the responses are female accounting for 79% of the total responses followed by male and non-binary with 19.90% and 1.10% respectively. The highest percentage of respondents were under the 25-35 age group with 38.80%. Moreover, 66.30% of the participants in this survey live in cities, 22.60% in towns, and 11.10% in villages. Participants with different levels of education participated in this online survey: 28.20% were Secondary school graduates, 40% had a bachelor's degree, which is the highest percentage, 30% had a master's degree, and 1.80% had a doctorate degree. The following map was created to give a quick overview of the content and highlights of the survey:

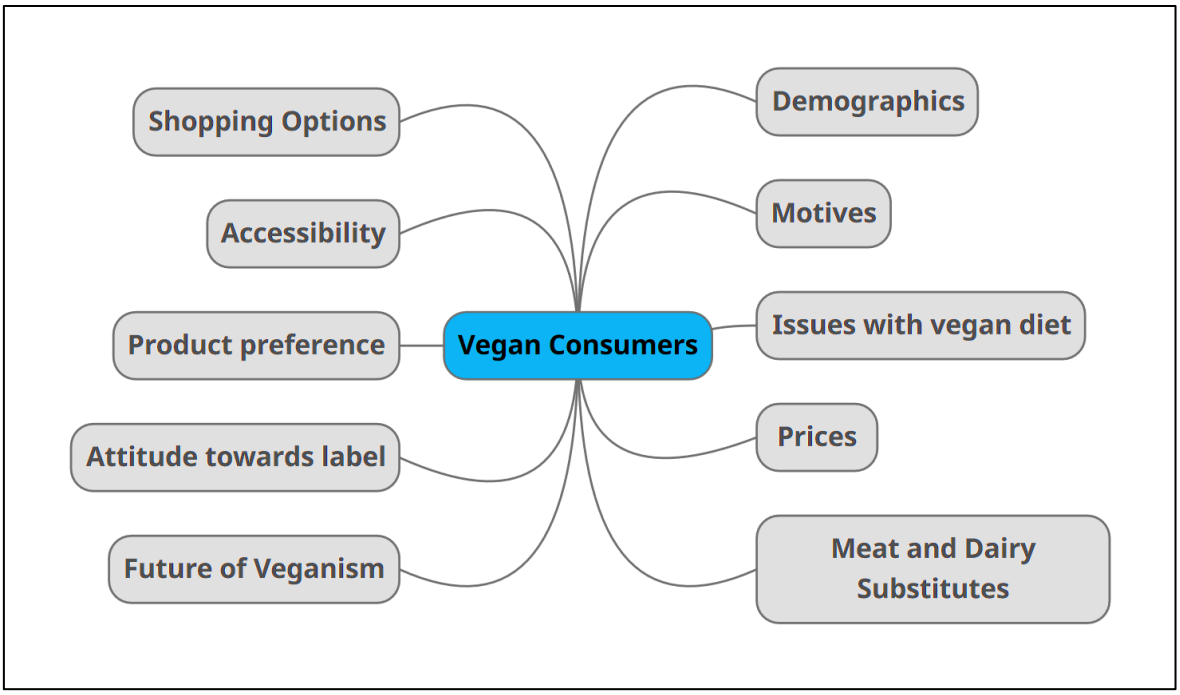


Figure 16. Survey Map (Author)

Figure 17 shows that the focus of the survey was on vegan consumers. Each of the above topics in the map has subthemes that cover related questions to the main theme.

The data collected from this survey is mainly represented by radar, also known as spider or web charts, pie charts, and clustered columns. Pie charts were mainly used to represent single variables, such as selecting the type of diet type or choice of preferred vegan product based on the origin of production. Clustered columns were used to represent or compare two or three variables. A radar chart was used to represent data with multiple variables.

The radar chart is a useful tool for comparative analysis and has some basic elements that help understand the message conveyed by a set of data. It starts with a central point, which is the core of the radar chart, and from which various axes are drawn. A radar chart has at least three axes

and each axis represents a variable and can also be given names. Once the axes are connected, a network is created where different variables are visualized by color-coding.

2.2 SURVEY RESULTS

2.2.1 Description of the vegan diet

The second section of the survey begins with a question asking participants to identify their diet. Of the 435 respondents, 95% were vegan and only 5% were vegetarian and flexitarian, as shown in the graph below. Although this survey was only intended for vegan consumers, the remaining 5% were also included in the analysis of the data.

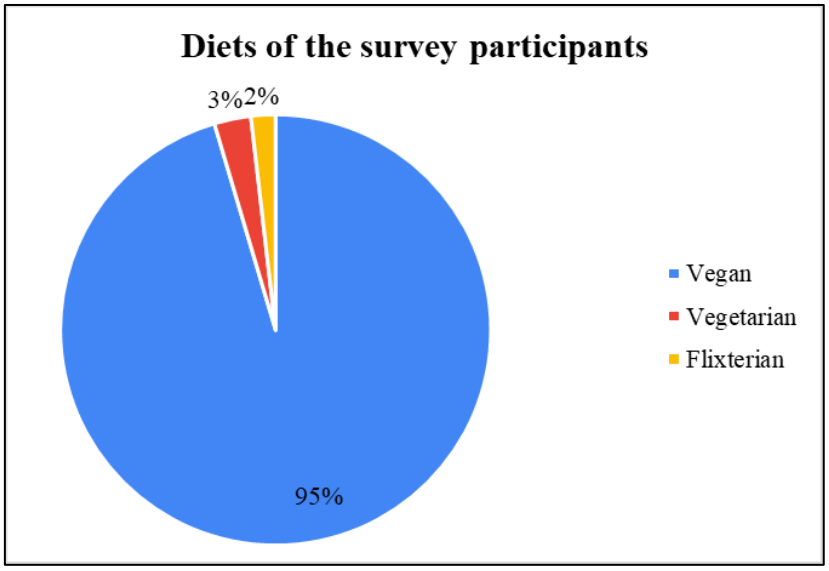


Figure 17. Diets of the survey participants

Almost one-third of respondents have been following a vegan diet for 5-10 years, accounting for 30%, and only 7% have been living vegan for more than 10 years shown by the figure below. The remaining 63% have been following a vegan diet for 1-4 years, which explains the fact that the number of vegans in Germany has doubled from 1.3% in 2016 to 2.6% in 2020, as described in the literature review.

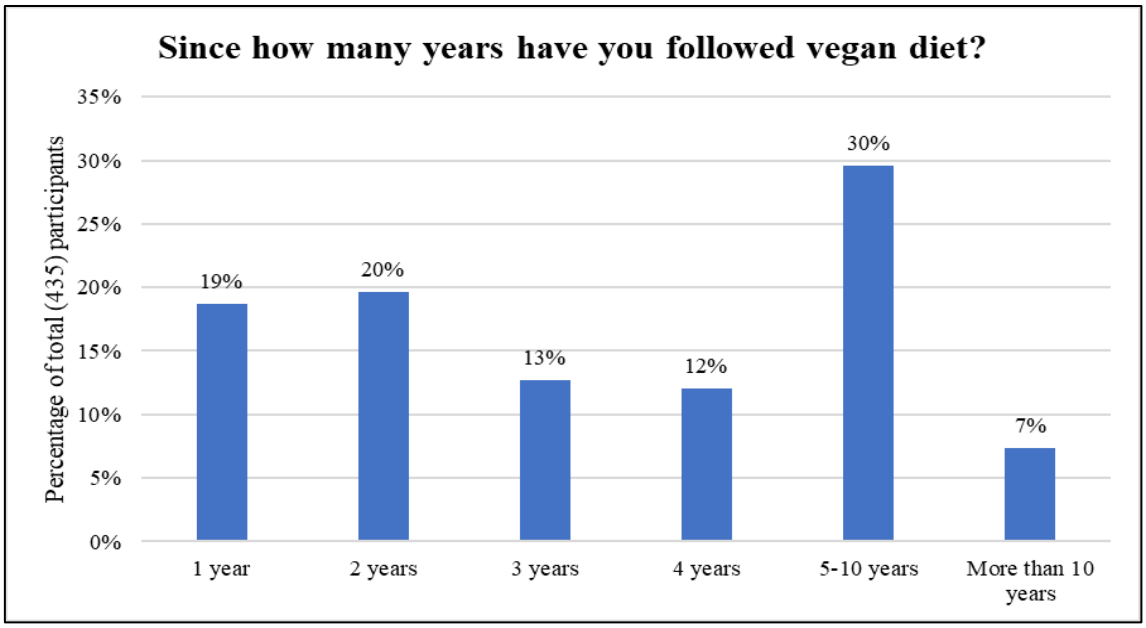


Figure 18. Number of years since following a vegan diet

Furthermore, the number of female vegans was significantly high compared to male vegans for all responses as shown in Appendix 3, however, there was an increase in both genders starting a vegan diet in the last 4 years. This segment was further analyzed based on the age group of the respondents and it also showed that more people aged 15-25 years, represented by the blue line in Appendix 3, stated following a vegan diet in the last 4 years, followed by the 25-35 age group. People older than 35 years in this survey made up the highest percentage who had been vegan for more than 10 years and 5-10 years.

However, personal reasons such as ethics, animal welfare, and health are not the only factors that influence the decision to go vegan. Friends, family, society, and media also influence an individual's decision to go vegan (Larsson et al. 2003). Therefore, the following question was included in the survey to find out how people in Germany deal with this issue. As Figure 21 shows, 79% of all respondents tried to encourage their relatives and friends to start following this diet. This point was further analyzed by finding out how the different genders responded to this question and it was found that all genders had very similar answers.

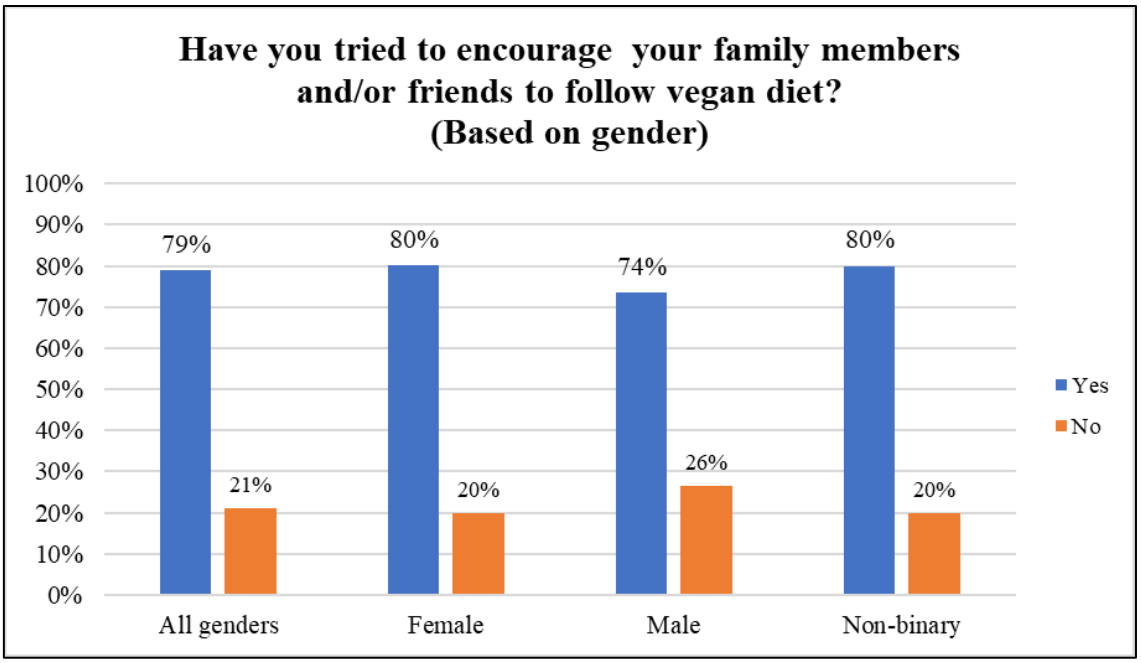
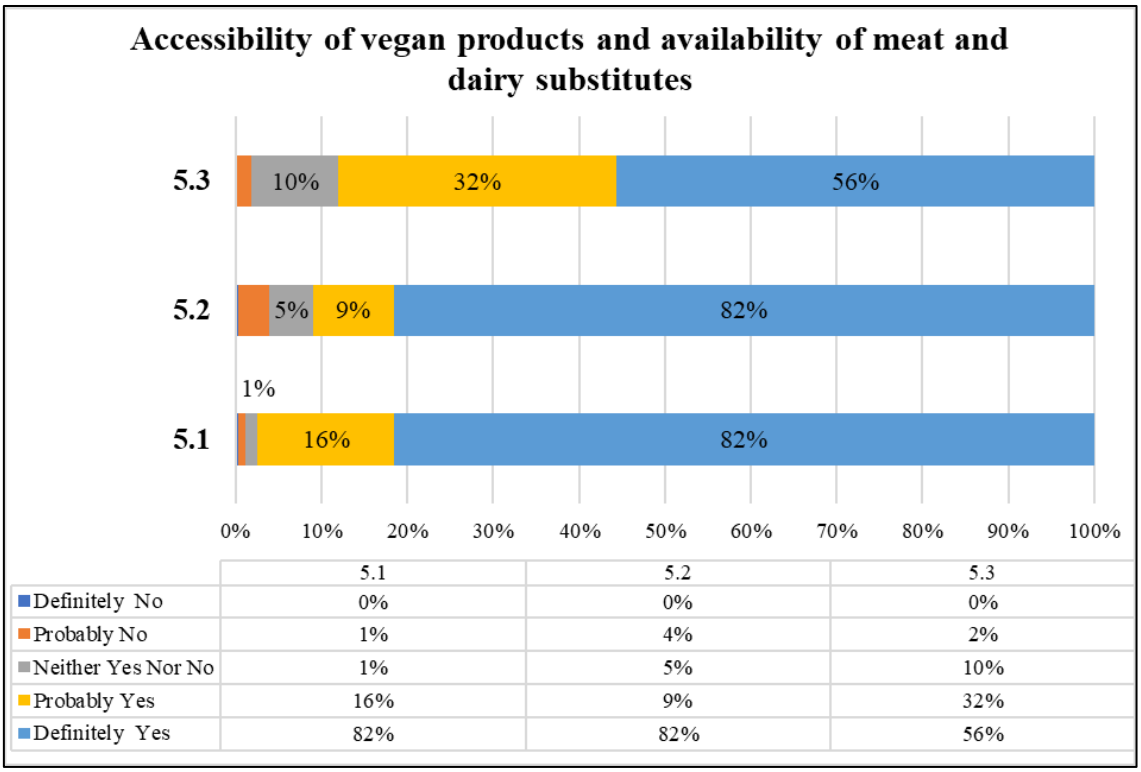


Figure 19. Encouraging family members and/or friends to go vegan based on gender

2.2.2 Access to vegan products in the supply chain

The majority of responses to the question of whether or not general access to vegan products and the availability of dairy and meat substitutes had improved pointed towards the 'definitely yes' and “probably yes” options. This suggests that vegan products are more accessible nowadays, with more vegan products entering the market each year and supermarkets creating more separate shelves for plant-based foods, as discussed in the literature review. The below figure shows that 82% of respondents selected "definitely yes" as a response to both "In your opinion, has overall access to vegan products improved compared to the last 5 years?" and "There are more meat and dairy substitutes in grocery stores now compared to 5 years ago." statements. The last statement in this segment, was "It is easy to be vegan nowadays", 88% of responses were positive, as 32% chose “probably yes” and 58% chose “definitely yes”. Only 2% said, “probably no”.



	5.1	5.2	5.3
Definitely No	0%	0%	0%
Probably No	1%	4%	2%
Neither Yes Nor No	1%	5%	10%
Probably Yes	16%	9%	32%
Definitely Yes	82%	82%	56%

Figure 20. Responses to 5.1[1], 5.2[2] , and 5.3[3] statements of the survey

The study also finds that labels play an important role for the majority of vegan consumers. when it comes to buying vegan products as most of the respondents stated that labels are important to them, but a comparatively low percentage have a label preference. The chart in Figure 21 shows that 22% responded "definitely yes" and 43% responded "probably yes" to the importance of labels on vegan products. In contrast, the label preference responses were 26% “probably no” and 16% “definitely no”. This means that most vegan consumers pay attention to labels on the products they buy, but not all have a specific preferred label.

[1] In your opinion, has overall access to vegan products improved compared to the last 5 years?
[2] There are more meat and dairy substitutes in grocery stores now compared to 5 years ago.
[3] It is easy to be vegan nowadays.

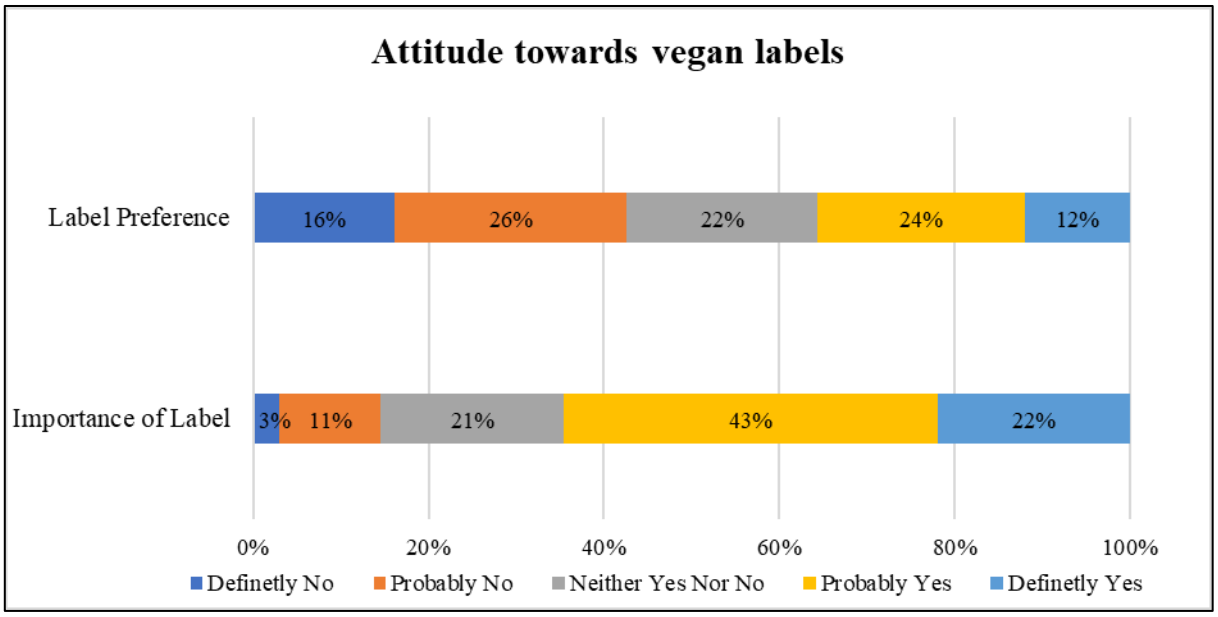


Figure 21. Attitude towards label preference and importance

This part of the survey is furthered analyzed by studying shopping alternatives of consumers who have label preference and those who do not have label preference. The data revealed the difference in the shopping options demonstrated in Appendix 6 where vegan consumers with label preference have a higher tendency to shop from local stores, local farmer's market, and vegan supermarkets while those who do not have label preference tend to shop more from ordinary supermarkets.

The literature review showed that vegan products are expensive compared to animal-based foods for the various reasons discussed. The results of the survey also show a similar result as 71% of the participants reported that vegan products are "more expensive" compared to ordinary products, as shown in the figure below:

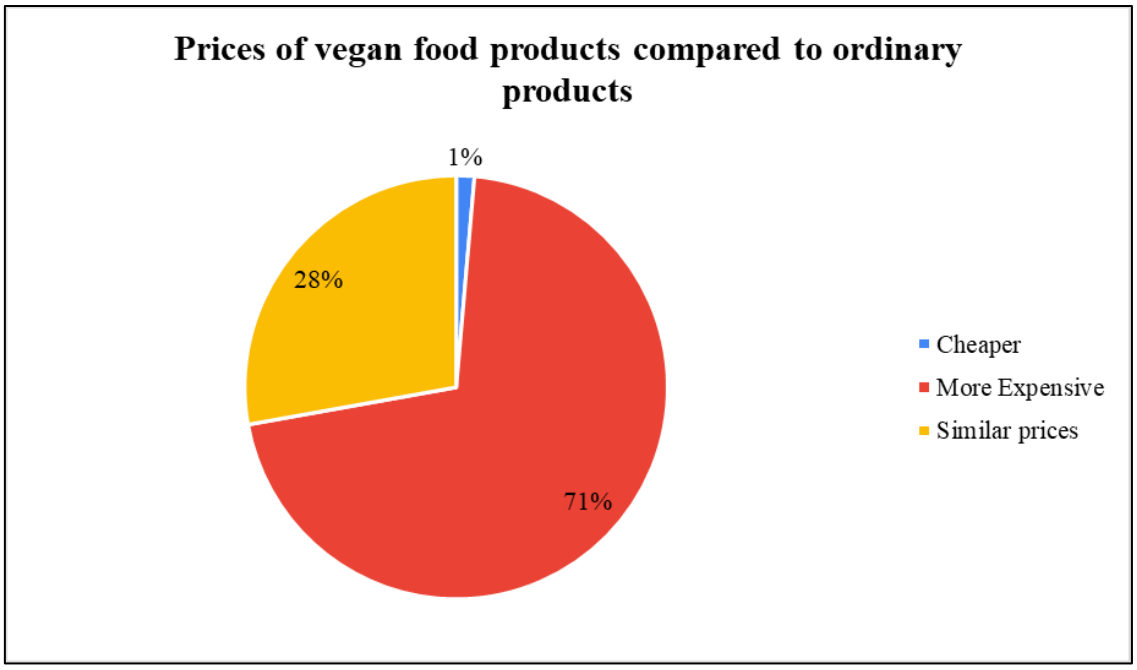


Figure 22. Prices of vegan food products compared to ordinary products

In addition, the gathered data related to the high prices of vegan products were analyzed based on age categories to understand which group is more likely to be able to afford these products. As shown in Appendix 5, in general, the majority of all age categories agreed that high prices are one of the main problems associated with the vegan diet, as there was a positive linear correlation (0.95) between responses about high prices and age groups. However, a lower percentage of the older age group (35+) agreed with the statement compared to the other two age groups as 44% selected "agree" and 8% selected "strongly agree". On the other hand, the responses of the 25-35 age group were 52% "agree" and 8% "strongly agree", moreover, 47% agreed and 17% strongly agreed in the 15-25 age group.

2.2.3 Retailers and vegan shopping alternatives

To understand the role and popularity of various retailers who are key stakeholders of the agri-food supply chain, respondents were asked to identify their shopping alternatives and indicate how often they would purchase vegan products from the given shopping alternatives.

The shopping options consisted of 7 alternatives that were categorized into two groups based on the results of the data collected: common (ordinary supermarkets, vegan supermarkets, local

stores, and local farmers markets) and uncommon (online, vegan cafeteria, and regular cafeteria). Appendix 6 shows that the majority of vegan consumers buy vegan products from ordinary supermarkets, as the responses were 41% "often" and 43% "always", represented by the blue line in the radar chart. The second most popular shopping option was local stores, followed by local farmers markets, and the least frequent option was vegan supermarkets, as 30% chose "never," another 30% chose "rarely," and 31% chose "sometimes."

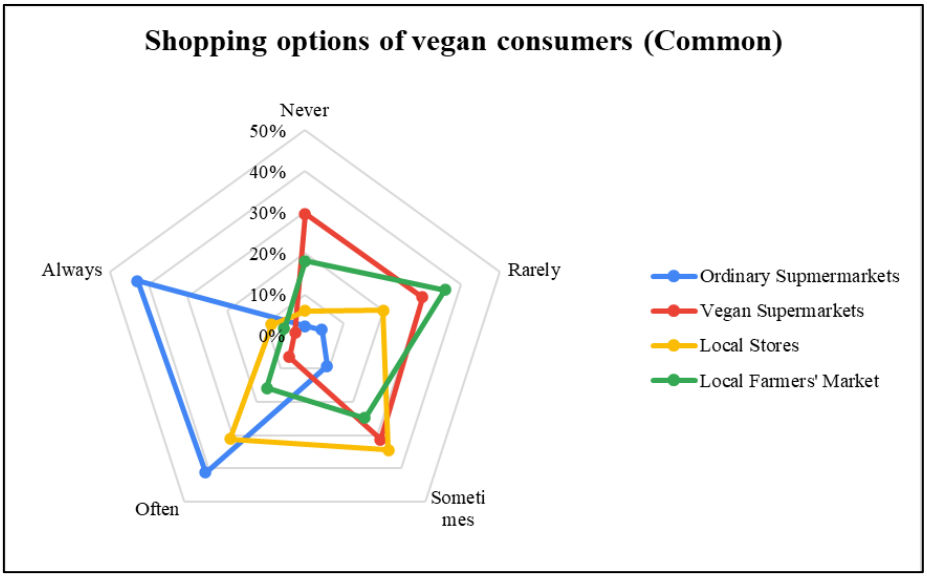


Figure 23. Common shopping alternatives

The figure below shows that vegan consumers were least likely to shop online, as 36% "never" purchased vegan products online and 35% said they "rarely" shopped. Between vegan and regular cafeterias, vegan cafeterias seem to be slightly more preferred by survey respondents. 14% said they 'often' go to a vegan cafeteria, compared to 13% who chose the same answer for a regular cafeteria. Only 4% chose 'always' for a vegan cafeteria as a shopping option and 1% chose 'always' for a regular cafeteria.

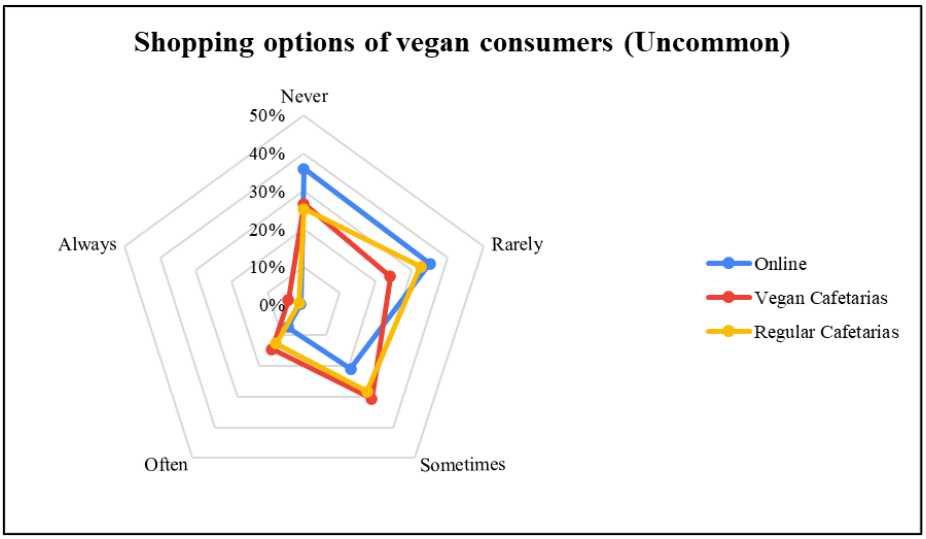


Figure 24. Uncommon shopping alternatives

The shopping alternatives of vegan consumers were further analyzed based on where they lived. As shown in Appendix 6, the regular supermarket was the most common shopping option, regardless of whether they lived in a city, town, or village. However, shopping at local stores was reported to be more common in towns than cities and even more common in villages than cities and towns. 30% of city residents "often" shop at local stores and 7% "always" shop at local stores, 33% of people living in the towns are "often" going for shopping and 9% reported "always" going to local stores, this percentage is higher in villages as 35% "often" shop at local stores and 17% "always" shop at local stores according to this survey. In addition, vegan supermarkets, represented by the red line in the radar charts, show that people in cities are more likely to shop there compared to residents of towns and villages.

2.2.4 Motives and issues related to vegan diet

The literature review showed that environmental issues are one of the main motivations among vegan consumers, therefore they prefer products that have a lower environmental impact and are produced organically. The survey aimed to show how important this aspect of veganism is for vegan consumers in Germany. The following chart shows the answers to this question:

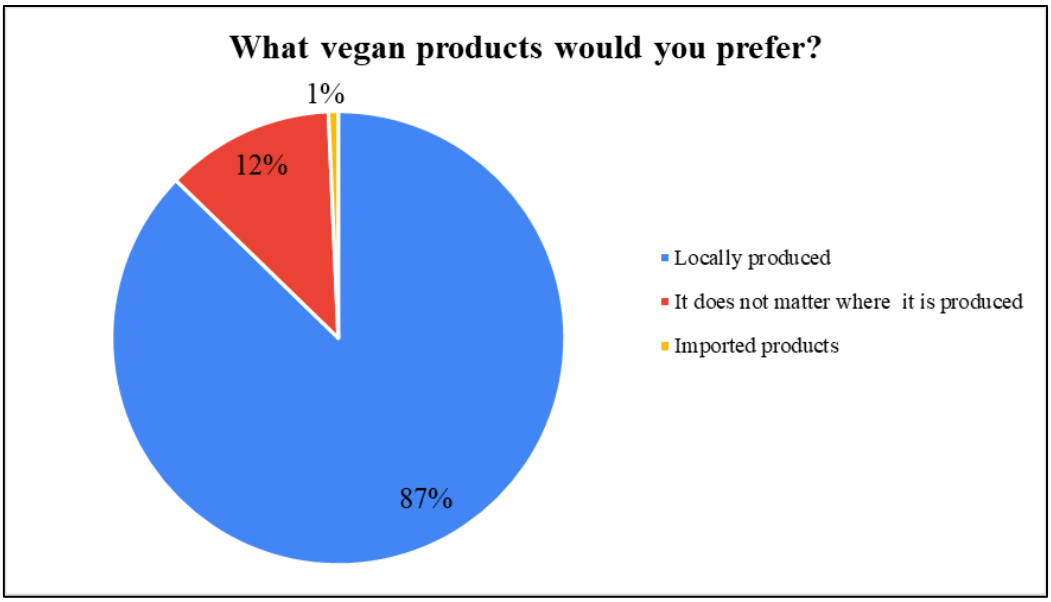


Figure 25. Product preference based on the origin

The survey also included a question about the main problems faced by vegans in Germany. A series of problems were listed to which participants could respond by selecting one of the answers (strongly disagree, disagree, agree, and strongly agree) to each issue. The responses to this question are presented visually alongside the data table in Appendix 7. 'High prices' for vegan products appeared first as the main problem, followed by lower accessibility, social judgment, lack of information about ingredients, getting enough nutrients, and hard to cook that came in second, third, fourth, fifth, and sixth respectively. The results of this part of the survey show that accessibility to vegan products is still a major problem, although it has improved compared to 5 years ago.

The literature review revealed that there are various motives such as ethical reasons, environmental protection, and health concerns that have led to a significant increase in the demand for vegan products and a vegan diet among consumers in developed countries (Radnitz et al. 2015; Janssen et al. 2016; Simons et al. 2021). This research found that consumers' motives for adopting a vegan diet revealed that animal welfare scored the highest, as 81% of respondents chose the answer "very important", followed by environmental concerns at 70%, and 50% indicated health reasons as an "important" motive for adopting a vegan diet. Social pressure, on the other hand, was the least important motive with 87% selecting “not important” and only 10% selecting social pressure as an important reason. Appendix 4 shows a clearer picture of the

importance of the different motives for vegan consumers. The results of this part of the survey are largely consistent with the reasoning in the literature review.

Finally, the survey included a short closing question asking if veganism will become more popular among people or if there will be more vegans in the future. And the responses showed that 95% said "yes", 5% chose "maybe", and none of the survey participants chose "no" in response to this question.

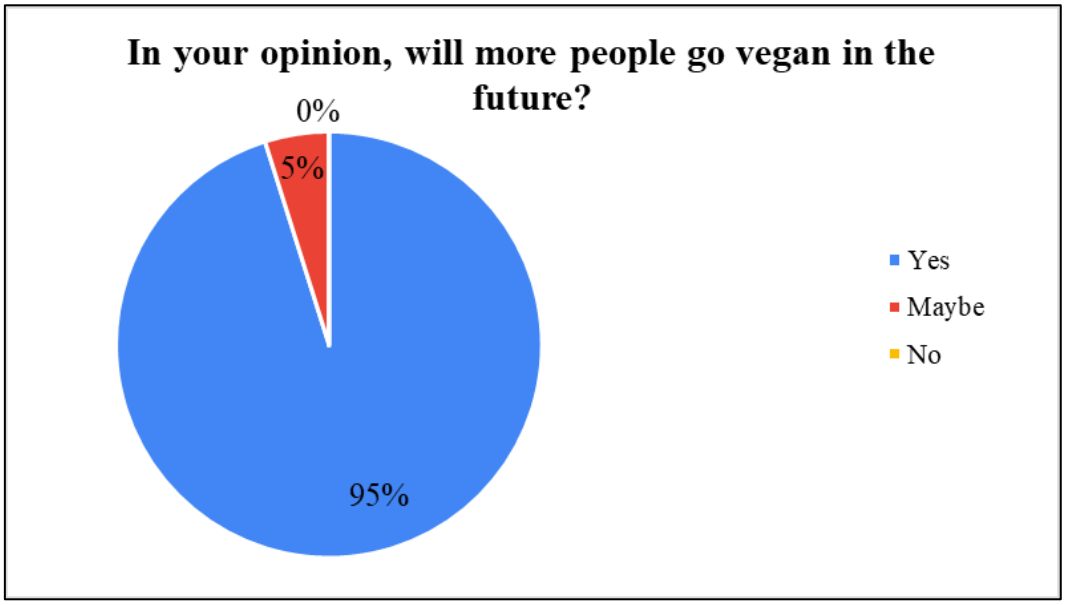


Figure 26. Number of vegans in the future

Vegans in Germany are optimistic that more and more people are adopting this lifestyle, and this argument is supported by the fact that their numbers have doubled since 2016, along with a significant increase in the annual introduction of vegan products in various countries, including Germany.

2.3 DISCUSSION

2.3.1 Vegan food market and consumption trends in Germany

Recent trends in the German food market are influenced by several factors, including the increasing demand for healthy and nutritious food by the aging population, the sharp increase in the production of organic food, as two-thirds of the German population believe that food choices can have a direct impact on their health, and the faced-paced lifestyle that leads consumers to demand more baked goods, frozen and ready-made food items (Germany Trade and Invest 2020).

Furthermore, veganism, which is described as a dietary trend, has received a lot of attention not only in Germany but around the world. The fact that veganism and other sustainable food practices are spreading is a part of modern agriculture, which is shaped by social and ecological views. Sustainable food systems act as a policy platform to promote innovations and agricultural practices that could contribute to sustainable development goals. United Nations Committee on world food security is the main driver of this platform at the global level (Niederle and Schubert 2020). In addition, a policy recommendation to reduce meat consumption has been issued from Intergovernmental Panel to Climate Change (IPCC) (Lawo et al. 2020).

In Germany, as part of the vegan trend, there are more and more vegan food alternatives in supermarkets and stores of all kinds. These products include a variety of spreads, meat and dairy substitutes, and ready-made food products. The demand for vegan products is increasing and the food industry is responding in a number of ways. For example, the establishment of the vegan supermarket chain "Veganz", the provision of vegan food in onboard restaurants of German Railway Deutsche Bahn, the increase in the selection of vegan products in supermarkets and many online shops offer vegan goods and services. More people are encouraged to buy vegan products and even change their diet because of the increased availability and accessibility of products (Gerke and Janssen 2016). The increasing demand is also reflected in the fact that more than half of the respondents have started a vegan diet for less than 4 years and also expect more people to follow a vegan diet in the future.

Berg and Henriksson (2020) explain that online stores nowadays offer food products that are associated with the ideology and ethical values of a certain group of consumers, such as organic, locally produced food, vegetarian and vegan products. In addition, people tend to spend their time on activities that have a higher value, such as sports, spending time with family, or reading, instead of going to the store to buy food. However, the results of the survey showed that online shops are not the most important shopping source among vegan consumers in Germany, but ordinary supermarkets were identified as the most common shopping option. The spread of the vegan lifestyle thus requires wider access to mainstream products. At the same time, the AFSC is also responding to demand by offering vegan products through regular chains.

German society is highly alerted about modern animal agriculture and often criticizes companies that treat animals badly and therefore consumers boycott buying animal products. Moreover, scandals related to meat were widely reported in the media and people reacted to any news that further damaged the reputation of this sector. Socio-demographic analysis shows that in Germany, a high percentage of women follow a vegan or vegetarian diet compared to men, and this is because women are believed to have a higher level of empathy towards animals (Simons et al. 2021). Similar results were reported in the survey where the number of female respondents was very high (79%) compared to male respondents (19.9 %).

Well-known celebrities on social media such as Ariana Grande, Miley Cyrus, Beyonce, and Jennifer Lopez, and many other influencers promote veganism by posting their vegan diets on social media, which has a huge impact on society, according to digital marketing experts. Celebrities in most cases act as role models and could influence their fans in various ways through their popularity on social media as millions of their fans follow them. In recent times, celebrity engagement has indeed contributed significantly to the rise of veganism by changing the image of this lifestyle. Moreover, they played a key role in destigmatizing veganism by giving it positive attention. Veganism received so much media attention in 2014 that it was named "the year of vegan" (Clinton, 2019; Lundahl 2020). Results of the survey also demonstrated that it is easy to be vegan nowadays as 88% of the respondents agreed to the statement. However, 46% agreed to social judgment being one of the main issues for vegans, which means that despite big steps taken towards destigmatizing veganism it is still not fully accepted in societies.

Phua et al. (2020) also note that social media is a fundamental driver of a vegan/sustainable meat-free diet, which explains the prevalence of Millennials adapting to this lifestyle as they engage heavily on social media platforms. In 2019, there were more than 95 million posts with the hashtag #vegan or #veganism on Instagram. Not only did these posts come from consumer accounts, but vegan commercial brands such as Tofurky, Yves Veggie Cuisine, Sweet Earth, and Beyond meat used Instagram to promote veganism and vegan products and communicate with end consumers. Clinton (2019) pointed out that there was a significant increase in searches on the topic of "veganism" revealed by Google search data. Information for search engines such as Google, etc. could be used to manage and monitor market trends and adjust the supply chain as responsive measures.

Furthermore, the study by Lawo et al (2020) shows that most vegans today are influenced by social media as one of the respondents said that the idea of switching to a vegan diet came from watching videos on various platforms such as Facebook, Instagram, and YouTube. People are motivated by consuming video content and also use the internet to validate and obtain information related to diet.

Owners of high-tech companies and billionaires such as Bill Gates, Sergey Brin, co-founder of Google, Biz Stones, and Evan Williams, founder of Twitter, are investing heavily in vegan startups because they see a promising future for this sector and are convinced of its high potential. For example, Jeff Bezos, the founder of Amazon, invested $30 million in a company called "The Not Company (NotCo)", which uses Artificial Intelligence (AI) in combination with food technology to produce sustainable meat-free products (Supply Management 2019).

To get a better insight into the trends and vegan market in Germany, it is better to have a look at the hot topics, reports, and news that have been spread and discussed by the interested circles. The following table shows some important news titles that have been published in Germany in recent years:

Table 5. Vegan News in Germany

Vegan News in Germany	Source
"According to Nielsen data, plant-based milk comprised 15 percent of total milk sales in 2018."	Bielinska et al (2020)
"Over 3,000 Vegan Activists March for Animal Rights In Germany."	Plant-Based News (2020)
"Beyond Burgers Sell Out 'Immediately' At German Lidl Stores, Causes Surge in Company's Shares"	Plant-Based News (2020)
"McDonald's Launches Vegan Burger in Germany"	Plant-Based News (2020)
"Research Says Vegan Products Almost Doubled Between 2014 – 2017"	Vegconomist. (2018)
"German consumers are becoming more sustainable and are making their purchases accordingly. Just like the clean label movement, growing demand for sustainable products is 'pushing' the food industry to come up with new innovative solutions."	Bielinska et al (2020)
"Meat substitutes are the most popular processed vegan products in Germany, reaching US$ 200 million in sales last year"	Bielinska et al (2020)
"Over 40% Of Germans Have Ditched or Reduced Meat, Says Report"	Plant-Based News (2020)
"Burger King to Launch Plant-Based Chicken Nuggets in Germany"	Plant-Based News (2020)
"Vegan Food Sales in Germany Spike 37% In First Quarter"	Pritchett (2020)
"Germany turns out to be a global hub for vegan startups"	EuroMeatNews. (2018)
"During the period from 2015 to 2021, the number of vegan restaurants in Germany increased from 137 to 242."	Simons et al. (2021)

2.3.2 Discussions on the vegan consumer's survey

Understanding consumer behavior is a key element to a company's success because it helps companies know what aspects influence a consumer's purchasing decisions. This knowledge can provide clear insight about the vegan consumer to improve their shopping experience by taking the necessary steps and customizing products accordingly. Consumers today have a high level of awareness due to the wide access to information sources on the internet, and as discussed in the literature review, vegan consumers in Germany also pay close attention when purchasing food and buy the products that meet their criteria and preferences. Some of the key findings of the vegan consumer survey are as follows:

- One of the most important motives for vegans in Germany is animal welfare. Vegan consumers prefer animal-free products, where in the production and processing neither animals nor animal ingredients are used. This affects the entire supply chain in a way that there must be transparency on the source of produce and processing conditions and technologies. In some cases, it may be easy in the supply chain to prove that a product is vegan and meet the criteria for labeling. However, it is also possible to face some challenges as there could be resistance to prove the information and the motive could be higher prices of the products.
- The youngest age group (15-25 years) of the participants accounted for the highest number of people who started a vegan diet in the last 4 years. This information may be important for marketers, especially advertising managers, in identifying their potential customers. And it asserts that the agri-food supply chain can be influenced considerably in the future as the diets are shifting in the coming decades.
- The fact that veganism is trending at a high level in Germany is also due to the fact that family members and friends play a major role in influencing each other's dietary choices and lifestyles.
- The accessibility to vegan products has greatly improved compared to 5 years ago. It signifies that the AFSC has reacted to demand and started to offer vegan products through conventional chains. However, it is still one of the main problems for the vegan

consumer as the demand for new and more vegan products is still high and is expected to increase according to the survey.

- Most vegan consumers tend to search for a label from a vegan certifying organization and chose a product based on their personal brand belief. Moreover, 65 percent of the respondents in the survey agreed to the importance of labels on vegan products. The impact on the supply chain is that all stakeholders should meet these criteria to be compliant. It also leads to an increase in the relevance of labels when new products are introduced. More information should be provided on labels as it helps consumers to easily identify products based on the label they prefer.
- The (35+) age group can afford more vegan products compared to (15-25) and (25-35). But as they get older and their income level increases, the demand will also increase which will have an impact on the AFSC.
- Seventy percent of customers surveyed said that vegan products are priced higher compared to non-vegan products. It is important to consider the affordability of vegan products along with other aspects. If the consumer is not able to buy the product because of the high price, it will fail in the market no matter how sustainably it was produced and how many authentic labels it has.
- Almost half of the respondents cited a lack of information about ingredients as the main problem. The information needs to be gathered from all the stakeholders in the chain to guarantee the vegan origin of a product. Overcoming this problem by the supplier of vegan products can be a crucial step to meet the demands of this group.
- Locally produced vegan products were preferred by 87% of the respondents in the survey. The strong preference for local food and the expected increase in demand for nationally certified vegan products will encourage the development of short supply chains and increase the competitiveness and power of local stakeholders. Many cheap food products are produced abroad and travel through long supply chains. As demand for vegan products increases, it will be a challenge whether all stakeholders and links in the chain can prove that they are vegan certified or not. The parts of the supply chain in other countries will need to be able to invest in building credibility as vegan suppliers. The pressure to shorten the number of links, and therefore the supply chain, may also come from the need to move products faster, especially if they are less processed, and to

try to minimize environmental impact, as consumers are demanding. So I would suggest that there are several development paths in supply chains at the same time - on the one hand, the increasing importance of short supply chains, and on the other hand, still the pressure for the cheap food that can come from the other side of the world through complex supply chains.

- However, a very small percentage reported shopping at local stores and local farmers markets. Part of the problem may be accessibility and convenience, e.g. local markets and their opening hours may not be convenient for people who work full time and require extra effort to visit, so the importance in the supply chain may not be as high as one might expect. Promoting these alternatives and addressing the issues that make people less likely to visit local farmers markets and stores can be a very effective step as it helps consumers by meeting their demand and also boosts the local economy. For veganism to spread widely, the regular supply chain must provide the products and make them easily accessible to consumers.
- The environmental friendliness of vegan products is an important factor as it is one of the main motivations to go vegan. Food companies that produce vegan products take this point into consideration and most of these companies get themselves labeled as vegan by independent certification organizations. Stakeholders in the agri-food supply chain need to be highly aware of this issue, they need to know about the regulations, the origin of the inputs, and the upstream stakeholders. The information gathered should be made available to all downstream stakeholders, including consumers.
- Vegan supermarkets are not yet very popular, partly because there are very few of them compared to ordinary supermarkets. The majority of vegans in Germany go to normal supermarkets and as discussed in the literature review, supermarkets around the world are increasingly adding more shelves just for vegan products. Therefore, shopping in a nearby ordinary supermarket is more convenient and supermarket brands like Veganz can face tough competition when entering the market.
- Vegans in Germany are very optimistic about more people going vegan in the future as their number continues to rise.

2.4 CONCLUSION

1. Each actor in the food chain has an important role to play at the individual level while maintaining close coordination with other stakeholders. A strong communication network can help food suppliers to work effectively and efficiently. The most important stakeholder in the food supply chain is the consumer, as they ultimately pay for the product and decide whether or not to buy a product based on their preferences and consumption patterns. Thus, they ultimately impact all other upstream stakeholders in the supply chain. Although consumers are not the only party that pays the price for a product, it is also the environment that pays a high price for some of the products that are produced around the world in an unsustainable manner that causes pollution, land depletion, overexploitation of natural resources, and even animal abuse. From the farm to the fork, everyone involved in the food chain has a responsibility to do their part and take steps to protect the environment and practice sustainable production practices. Sustainability can only be achieved by involving everyone in the entire food supply chain. Starting with the farm, reducing the use of hazardous chemicals and pesticides is an important step, processors and manufacturers can do their part by promoting and using green energy for their operations and using less plastic for packaging, retailers can play an important role by choosing organic products from local farms, and finally, consumers can help by choosing and supporting environmentally friendly products and reducing food waste.
2. Innovation leading to efficiency in the food sector is one of the most important elements in dealing with environmental issues. In the past, the only goal in developing a new machine or technology was to increase output and productivity and ignoring its' impact on the environment. These innovations caused most of the disruptions we see today, including forest fires, global warming, the extinction of many habitats, etc. Continuing the same unsustainable practices will cause further irreversible damage from which we will never recover. Technological advancement and consistent investment in R&D and IT throughout the supply chain including farming methods, processing and manufacturing technology, packaging, and many other areas are crucial and have been proven successful in overcoming inefficiencies and reducing environmental impact.

Innovation has the potential to fundamentally change supply chain relationships among stakeholders. For example, consumer information flowing through ICT to producers, also back from producers to end consumers. Overcoming these problems can lead to an increase in the efficiency and productivity of the AFSC as it seeks to adapt to rapidly changing demand from consumers with specific preferences.

3. The trend towards a plant-based diet in Germany has had a significant impact on the agri-food supply chain, leading to increasing demand for meat and dairy substitutes as meat consumption has declined in recent years. German vegan consumers exclude animal products from their diet for various reasons such as animal welfare, environment, and health issues. Vegan foods are not only consumed by vegans but also many vegetarians and omnivores show great interest in buying these products. The percentage of vegan women is significantly high compared to men, but the numbers are increasing regardless of gender as demand increases. However, it might be difficult to satisfy this demand by food companies, as providing such products considering all criteria and the values and motives of vegan consumers might drive up production costs. High prices, lower accessibility, and lack of information on ingredients are still mentioned as the main problems related to a vegan diet.
4. The agri-food industry, as a consumer-driven sector, is responding to changing dietary behavior by launching many new plant-based products each year and improving access to vegan products by regular supply chain stakeholders in Germany. Ordinary supermarkets are the main and most accessible supplier of vegan products, but new players such as vegan supermarkets have also emerged in the retail chain. The results suggest that access to meat and dairy substitutes has improved in recent years. 65% of respondents emphasized the importance of vegan labels. Vegans influence AFSC in a number of ways, as they want to know about inputs, growing and processing conditions, and the origin of the products. The strong preference for local food is leading to an increase in demand for nationally certified vegan products and is expected to promote the development of short supply chains and increase the competitiveness and power of local stakeholders. More and more young people are switching to a vegan diet and this change in dietary habits is expected to impact AFSC in the coming decades.

SUMMARY

The research gap that this thesis aimed to fill was to study the influence of dietary trends (especially veganism) on the agricultural and food supply chain in Germany. The aim was to explore the impact of the increasing demand for vegan products on the AFSC, using Germany as an example. The objectives of the thesis were to discuss the role of AFSC stakeholders, provide an overview of AFSC innovations and efficiencies and how they relate to the environment, discuss veganism and its trends and motivations, and analyze the impact of the increasing demand for vegan products on AFSC in Germany.

The research method involved obtaining secondary data from academic papers, books, blogs, online journals, etc., and primary data was collected through an online survey using a convenience survey approach. The number of participants was 435 from different age groups, genders, and educational backgrounds and more than half of them had been following a vegan diet for four years or less.

The literature review explored the role and importance of consumers as they were identified as the most important stakeholders. Countries around the world are investing in developing technologies that meet the needs of today's world and technologies that are less harmful to the environment as AI and the digital revolution are already transforming the agri-food industry. Operational inefficiencies in AFSC lead to resource wastage, environmental damage, economic problems, etc., and need to be addressed by introducing sustainable practices throughout the chain.

The empirical part mainly focused on the consumer and the results were integrated with secondary sources to compare and discuss the impact of a vegan diet on the AFSC. The main findings were that dietary trends such as veganism affect the entire supply chain as consumers' diverse preferences shape the agri-food industry.

The consumer survey has 435 participants and 63% of the respondents have been following a vegan diet for 4 years or less, which confirms the trend of increasing vegans in Germany discussed in the research literature. The increase in the number of vegans was particularly

characteristic of younger individuals. Thus, a shift in dietary habits can be expected in the coming decades, which will have an impact on the food supply chain.

The agri-food supply chain is already responding to these shifts in demand by introducing more new products each year. The results suggest that access to vegan products has improved in recent years, particularly the availability of meat and dairy substitutes, but still to some respondents being on a vegan diet was not easy. Challenges included higher prices for vegan products, lower accessibility, lack of information about ingredients, and social judgment from peers. 65% of respondents emphasized the importance of vegan labels. For the final product to be certified vegan, information must be available from the entire supply chain about their inputs, growing, and processing conditions of the raw material.

As one of the main motives for the vegan diet was animal welfare, the supply chain needs to comply with this by providing information on transparency, the origin of products, processing conditions, and technologies. For some stakeholders in the supply chain, it may be easy to meet the criteria for labeling, but resistance can be expected from others. Information needs to be collected and verified from all actors in the chain to guarantee the vegan origin of a product.

Some companies are considering the importance of labels, disclosing information about the origin of food products, striving to produce environmentally friendly goods, and improving accessibility. Vegan consumers in Germany are highly aware, demand more vegan products, pay attention to labels and the origin of food, stated high prices and accessibility as main problems, often buy food in ordinary supermarkets, prefer locally produced products, and strongly believe that the number of vegans will increase in the future. As ordinary supermarkets have been the most significant and accessible supplier of vegan products in the supply chain, the regular supply chain has responded to increased consumer demand and awareness, but new players have also appeared in the retail chain (such as vegan supermarkets).

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APPENDIXES

Appendix 1. Questionnaire Form

Questionnaire about vegan diet

Dear respondents,
I am a student of Agri-Food Business Management in Estonian University of Life Sciences. I am currently writing my final thesis entitled (Agri-Food Supply Chain - Veganism and its impact on the food supply chain in Germany). The questionnaire is about vegan diet and there are 10 questions which will take about 3-5 minutes to answer.

*Required

I. Age * *(Mark only one oval)*

☐ 0-15 ☐ 15-25 ☐ 25-35 ☐ 35+

II. Gender * *(Mark only one oval)*

☐ Female ☐ Male ☐ Non-binary

III. Place of residence * *(Mark only one oval)*

☐ Village ☐ Town ☐ City

IV. Education Level *

☐ Secondary School ☐ Bachelor's degree ☐ Master's degree ☐ Doctorate degree

1. Please choose your diet, if you are vegan, continue with the survey. * *(Mark only one oval)*

☐ Vegan ☐ Vegetarian ☐ Flexitarian

2. Since how many years have you followed vegan diet? * *(Mark only one oval)*

☐ 1 year ☐ 2 years ☐ 3 years ☐ 4 years ☐ 5-10 years ☐ More than 10 years

3. How important are the following motives as a vegan to you? * *(Check all that apply.)*

	Not Important	Important	Very Important
Animal Welfare	☐	☐	☐
Health reasons	☐	☐	☐
Environmental issues	☐	☐	☐
Social Pressure	☐	☐	☐

4. Have you tried to encourage your family members and/or friends to follow vegan diet? * *(Mark only one oval)*

☐ Yes ☐ No

5. Please respond to the following statements: * *(Check all that apply.)*

	Definitely No	Probably No	Neither Yes or No	Probably Yes	Definitely Yes
In your opinion, has overall access to vegan products Improved compared to the last 5 years?	☐	☐	☐	☐	☐
There are more meat and dairy substitutes in grocery stores now compared to 5 years ago.	☐	☐	☐	☐	☐
It is easy to be vegan in nowadays.	☐	☐	☐	☐	☐

Are labels of certifying agencies on vegan products important to you?	☐	☐	☐	☐	☐
Do you have a label preference when buying vegan products?	☐	☐	☐	☐	☐

6. How are the prices of vegan food products compared to ordinary products? * *(Mark only one oval)*

☐ Cheaper ☐ More expensive ☐ Similar prices

7. Which of the following shopping options do you use more often since starting your current diet? * *(Check all that apply.)*

	Never	Rarely	Sometimes	Often	Always
Online	☐	☐	☐	☐	☐
Ordinary Supermarkets	☐	☐	☐	☐	☐
Vegan Supermarkets	☐	☐	☐	☐	☐
Local Stores	☐	☐	☐	☐	☐
Local Farmers' Market	☐	☐	☐	☐	☐
Vegan Cafeterias	☐	☐	☐	☐	☐
Regular Cafeterias	☐	☐	☐	☐	☐

8. What vegan products would you prefer? * *(Mark only one oval)*

☐ Imported products ☐ Locally produced ☐ It does not matter where it is produced

9. The main issues related to following vegan diet are: * *(Check all that apply.)*

	Strongly Disagree	Disagree	Agree	Strongly Agree
High Prices	☐	☐	☐	☐
Getting enough nutrients	☐	☐	☐	☐
Lower accessibility	☐	☐	☐	☐
Lack of information on ingredients	☐	☐	☐	☐
Social judgement	☐	☐	☐	☐
Hard to cook vegan dishes	☐	☐	☐	☐

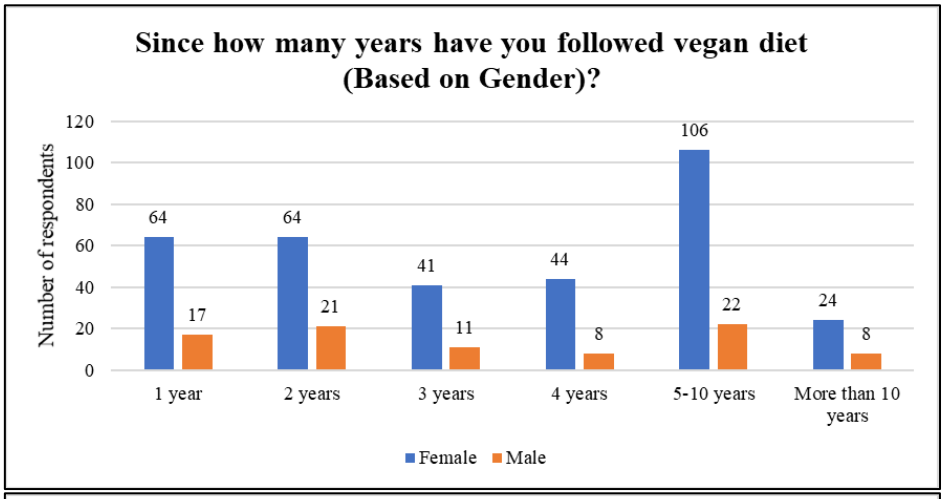
10. In your opinion, will more people go vegan in the future? * *(Mark only one oval)*

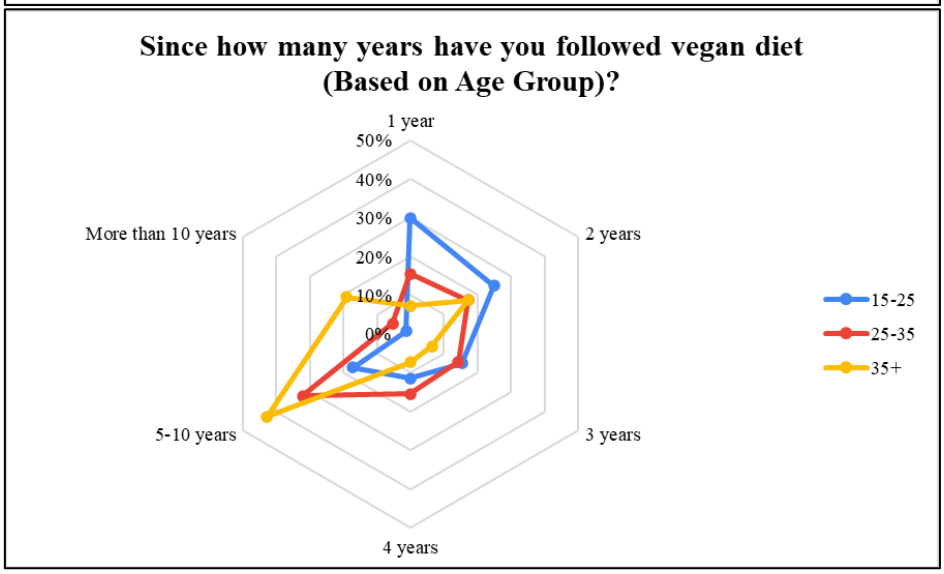
☐ Yes ☐ No ☐ Maybe

Appendix 2. The demographic information of the survey respondents

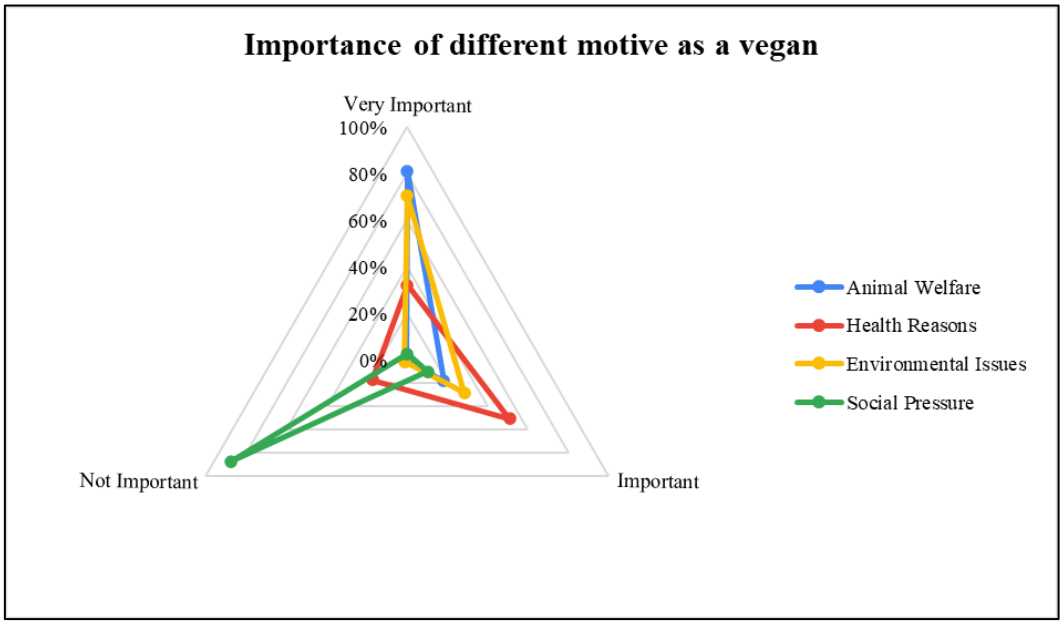
Variables	*Values*	*Percentage (%)*
Age	0-15	-
	15-25	36.30
	25-35	38.80
	35+	24.90
Gender	Female	79.00
	Male	19.90
	Non-binary	1.10
Place of residence	Village	11.10
	Town	22.60
	City	66.30
Education Level	Secondary School	28.20
	Bachelor's Degree	40.00
	Master's Degree	30.00
	Doctorate Degree	1.80

Appendix 3. Since how many years have you followed a vegan diet

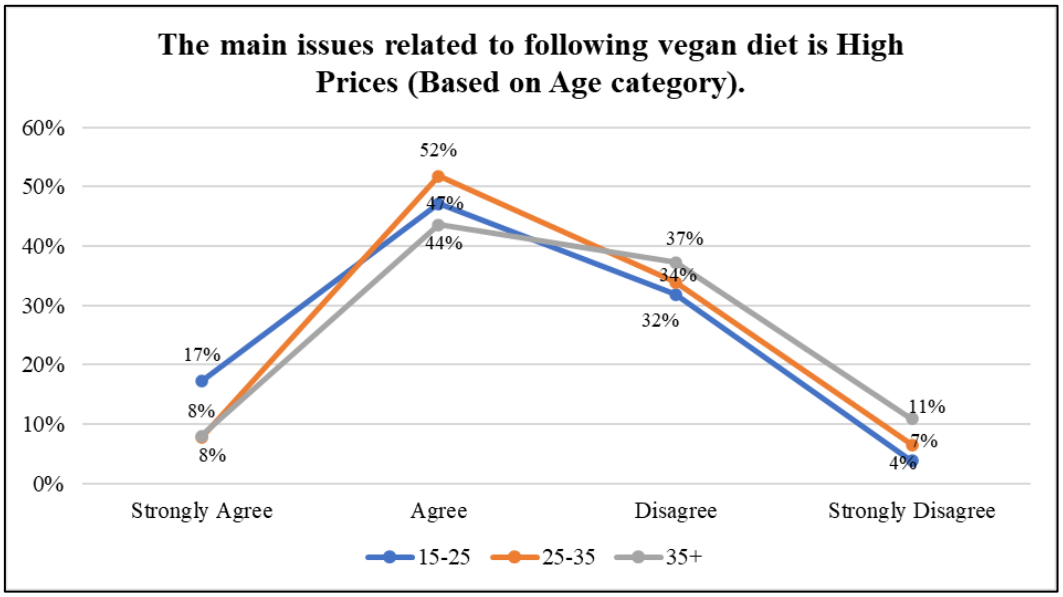




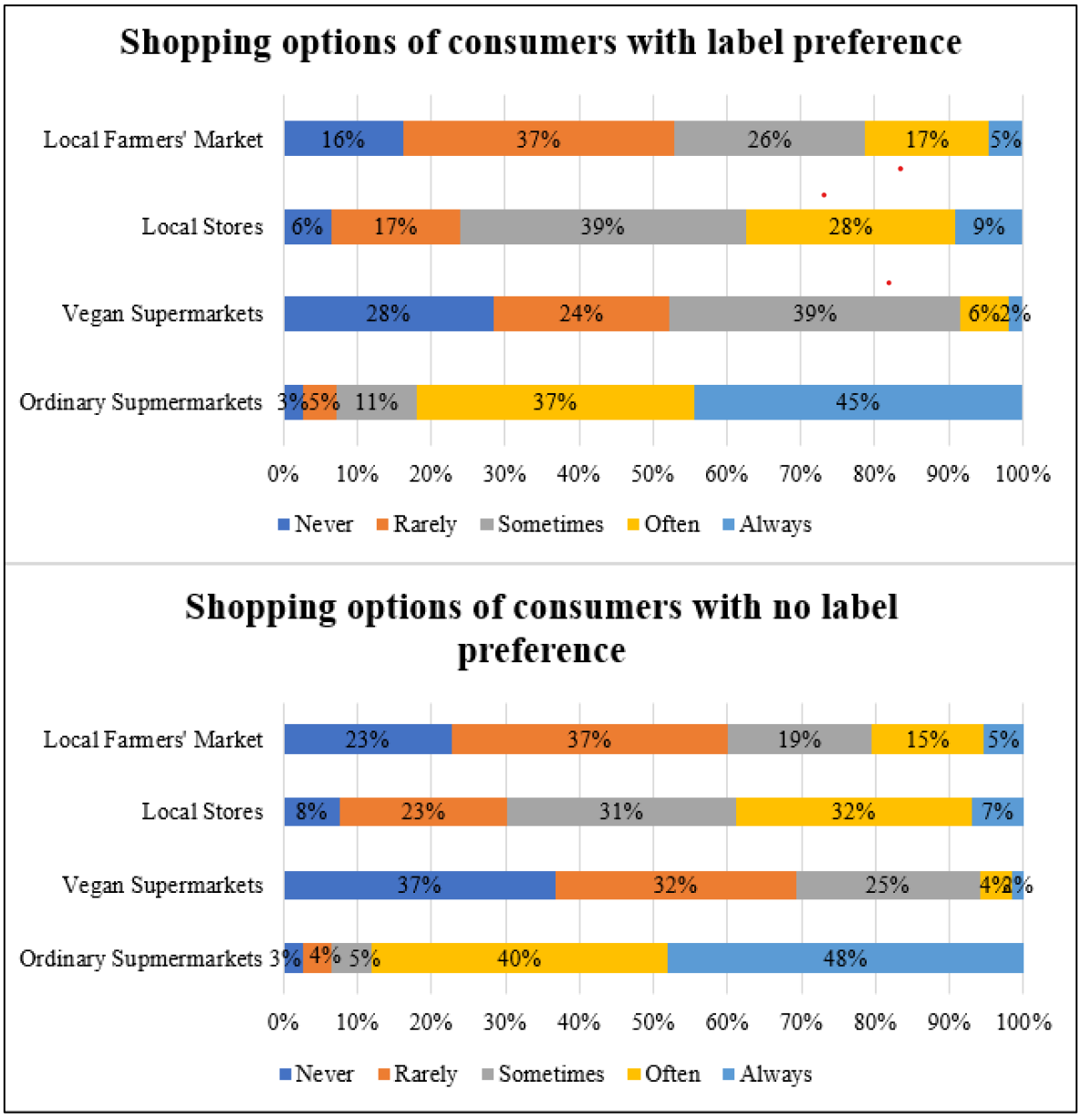
Appendix 4. Motives of vegan consumers



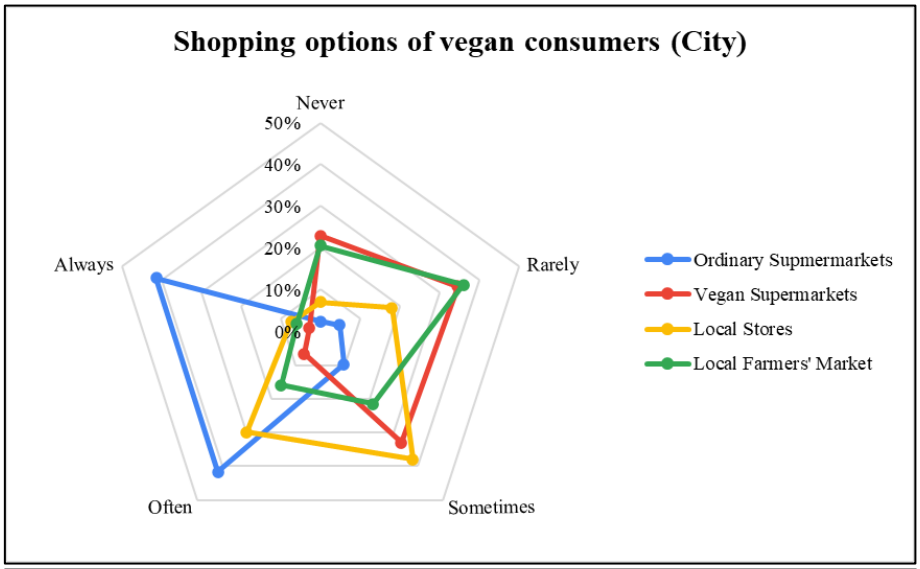
Appendix 5. Response to high prices of vegan products based on age category

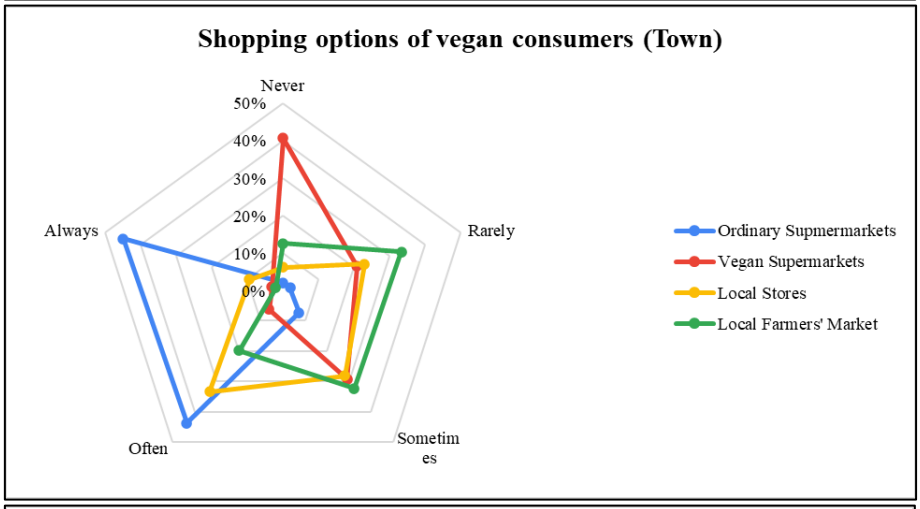


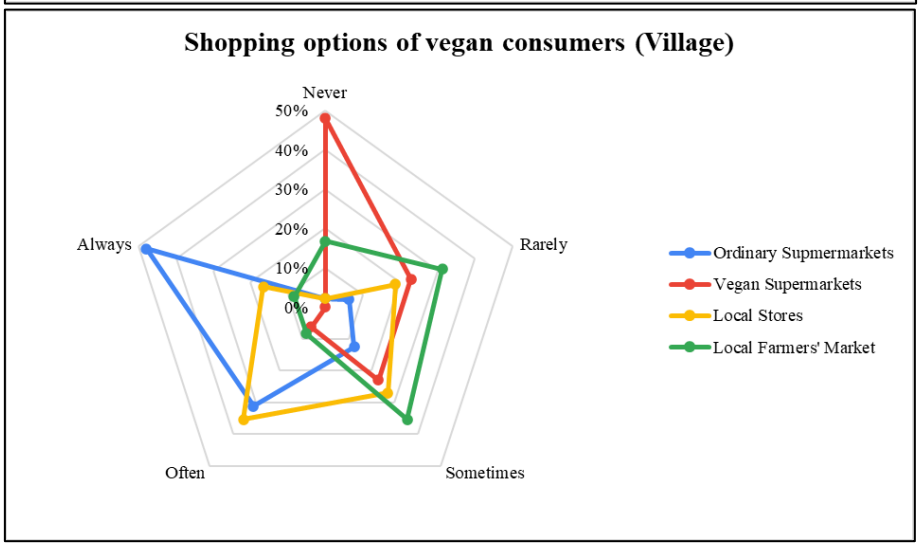
Appendix 6. Shopping options and label preference



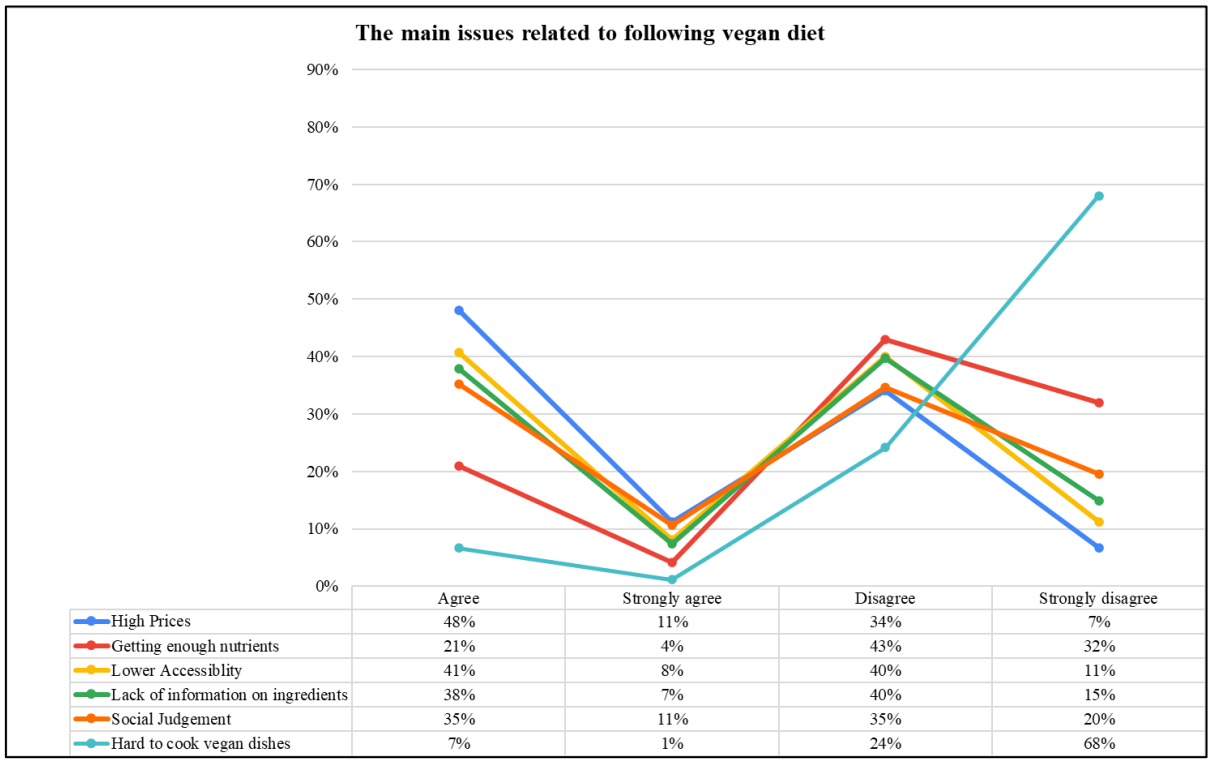
Appendix 7. Shopping options based on residence place







Appendix 7. Main issues about the vegan diet



	Agree	Strongly agree	Disagree	Strongly disagree
High Prices	48%	11%	34%	7%
Getting enough nutrients	21%	4%	43%	32%
Lower Accessiblity	41%	8%	40%	11%
Lack of information on ingredients	38%	7%	40%	15%
Social Judgement	35%	11%	35%	20%
Hard to cook vegan dishes	7%	1%	24%	68%

Appendix 8. Non-exclusive licence for depositing the final thesis and opening it for the public and the supervisor's (supervisors') confirmation for allowing the thesis for the defence

Hereby I, Ahmad Farhad Hedayat (28.03.1994)

1. grant Eesti Maaülikool, the Estonian University of Life Sciences, a free-of-charge non-exclusive licence to store the final thesis titled Agri-Food Supply Chain – Veganism and its Impact on the Food Supply Chain in Germany, supervised by Anne Põder, Ph.D. For

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This is to confirm that the final thesis is allowed for defence.

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Supervisor's name and signature Date

…… ……..

Supervisor's name and signature Date